GRINNELL VARIABLE PRESSURE ALARM VALVE

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Study of the action of a
four inch grinnell variable

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A Study

of

THE ACTION OF A FOUR INCH GRINNELL VARIABLE PRESSURE ALARM VALVE.

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A THESIS

Presented by

E.W.Hotchkin.

F.M.Pfaelzer.

to the

President and Faculty

of

ARMOUR INSTITUTE OF TECHONOLOGY

For the Degree of

BACHOLOR OF SCIENCE IN FIRE PROTECTION ENGINEERING

Having Completed The Prescribed Course Of Study In

Fire Protection Engineering.

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Preface.

Owing to the numerous variables which influence the action of an alarm valve it is impossible to put your finger on any one thing and say with certainty that that is or is not the cause of a certain result. In conducting the following tests, wherever possible, we have tried to study the effect of each variable separately by keeping the others constant throughout the particular test. In the following pages we have taken up the effect of flexibility on the sensitiveness of the valve, also the effect of service pressure, rate of flow, and flexibility, on the retarding factor of the valve, and have discussed them in that order.

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The Action Of The Grinnell Alarm Valve.

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The Action Of The Grinnell Alarm Valve.

In order to make a comprehensive study of the action of a Variable Pressure Alarm Valve, it has been necessary to coin certain new terms and establish certain arbitrary standards and accompanying definitions, in order to obtain a basis upon which to work. The use of the terms: Flexibility, Sensitiveness, and Retarding Factor, in this thesis are based on the following definitions;

Sensitiveness;

The Sensitiveness of an alarm valve is defined as the least number of gallons of water per. minute, which must be drawn from the system through the valve in order to cause an alarm.

Flexibility;

The Flexibility of a system is defined as the number of gallons of water which must be drawn off from the system in order to lower the pressure in the system ten pounds.

Retarding Factor;

The Retarding Factor is defined as the time

measured in seconds, elapsing between the first opening of the main check of the valve, (due to a flow of water), and the movement of the mechanism which actuates the alarm.

Description Of The Grinnell Alarm Valve.

The Grinnell Variable Pressure Alarm Valve is of the swing check type. The valve may be said to consist of two parts, the part which contains the check valve itself, and the retarding chamber. (See Plate A.) The valve disc A, is made of bronze and has a rubber face. The valve seat B, is also of bronze and has a groove running around its entire circumference.

The retarding chamber F, is connected to the valve by the pipe E, this leads to the groove in the valve seat. In the retarding Chamber there is a copper diaphram H. The valve J, is connected to this diaphram by a brass loop. G is the outlet to the circuit closer and K is the drain pipe.

The Action Of The Grinnell Alarm Valve.

When there is a greater pressure on the lower side of the check than there is on the upper the valve disc A, rises and allows the water to flow through the groove in the seat and thence to the retarding chamber. As the pressure in the retarding chamber builds up, the diaphram is forceddown and the valve J, closes off the drain connection. When this has taken place the pressure cannot be relieved and as a result it is transmitted through the connection G, to the circuit closer. If the flow through the valve is small the clapper will not rise long enough for the pressure in the retarding chamber to build up, and as a result the water will flow out through the drain pipe K.

The Action Of The Grinnell Alarm Valve.

Description Of The Apparatus Used In The Tests.

In conducting the accompanying tests it has been our aim to obtain as near as possible conditions actualy met with in practice, within the limits of the apparatus at hand, and at the same time to be able to control the system accurately. Further it is necessary to be able, after once obtaining certain conditions, to duplicate them should the occasion arise. The equipment at the Underwriters Laboratory is well adapted for this work. The alarm valves tested are connected to the valve stand located in the basement of the Laboratories. This stand was built especially for test purposes and consists of a six inch main running along the floor with short vertical risers, the size of which depend on the size of the valve tested. The valve to be tested is set on these risers, (See Plate 1.) in the manner shown. The valve E, is connected to another

four inch main near the ceiling by short risers. This main discharges into the cistern. The flow of water is controlled by gate valves of the outside screw and yolk type and also by quick action gate valves. A 500 gallon Quimby screw pump, driven by a 50 horse power General Electric motor, and taking its suction through an eight inch suction pipe from a 12000 gallon cistern, supplies the pressure tank A? and the system with water. The capacity of the pressure tank is 4500 gallons. Air is pumped into the tank and the system by a motor driven air compressor. A six inch stand-pipe O, seventy-five feet in height is used to obtain varying flexibilities, the range of which is from ten to one at seventy-five pounds service pressure. The head of water in the stand-pipe is measured by using an eighth four inch mercury gauge L, connected differentialy, one side being connected to the top of the standpipe by the pipe N? and the other to the bottom of the standpipe. The

action of the valve itself and the differential is observed by using a thirty-six inch differential mercury gauge F, one side of which is connected above and the other below the main check of the valve. Water is drawn off from the system through a set of calibrated nozzles attached at J, the rate of flow being regulated by the globe valve H, and the discharge pressure obtained by the gauge I. The nozzles discharge directly into the cistern. The service pressure is measured by the gauge C.

Method Of Setting The Syystem For Tests.

Since the flexibility and the action of the valve are materially effected by the amount of air in the system it is necessary in all the tests to be certain that no air is entrapped in the risers or the mains leading to the stand-pipe. In order to be sure that this condition is fulfilled, two pet cocks have been placed in the piping, one at the highest point of the horizontal main and the other in the stand-pipe about ten feet above the bottom.

The Action Of The Grinnell Alarm Valve.

In setting the system the pressure and water level in the pressure tank A, (See Plate A) are set to the desired amount. The pet cocks and the valve M, in the pipe leading from the top of the stand-pipe O, are opened. The valve D, in the riser, below the alarm valve is opened and the water is allowed to run into the system slowly thus driving the air out before it. After the water has filled the system up to the pet cocks and begins to flow from them in a steady stream they are closed and the valve D is turned off. The system is now filled with water to a point about ten feet above the bottom of the stand-pipe there being no air entrapped anywhere in the risers leading to it. The valve M, is then closed and the air pressure is pumped up to an amount equal to the pressure of the water in the system and in the pressure tank. The valve H is then opened and the valve D is opened wide. The system is now set and ready to begin tests.

The Action Of The Grinnell Alarm Valve.

(A). Calibration Of The Pressure Tank.

In order to obtain a service pressure of any desired amount and maintain this pressure for some time while water is being drawn from the system it is necessary to use the 4500 gallon pressure tank as a source of supply. From Data Sheet No. 1. and Plate No. 2. it will be seen that it does not make any difference in the action of the valve under test, where the level of the water in the pressure tank is. The only requirements are that the tank shall have a suffucient amount of water in it to supply the demand and that the air cushion over the water shall be large enough to prevent sudden fluctuations of pressure.

(B). Nozzles and Gauges.

All gauges used were calibrated on a Crosby Gauge Tester.

In measuring the flow of water from the system a series of calibrated nozzles were used.

(C). Calibration Of The Stand-pipe.

In actual practice it has been found that the amount of air entrapped in sprinkler systems varies considerably, and that this amount of air has a direct bearing on the flexibility of the system. Since we are endeavoring to duplicate actual conditions met with in the field it becomes necessary for us to calibrate our system for various heads of water and service pressures.

In preforming this work the system was set as described on Page 9. The head of water in the standpipe was read by means of the differential mercury gauge L, (Plate 1.). The standpipe was then cut off from the pressure tank by closing the gate valve D. By means of the drain valve H water was drawn from the standpipe until the pressure was reduced ten pounds. The water level in the standpipe was then read and the difference between the two water level readings gave the actual reduction of feet head in the standpipe necessary to cause the

ten pound reduction in pressure. Knowing the diameter of the stand-pipe to be six inches, the actual number of gallons withdrawn can be obtained and this value according to our definition is the flexibility of the standpipe at that particular head.

The gate valve D, is again opened allowing the water in the pressure tank to flow in to the standpipe. After equilibrium has been established air is withdrawn from the top of the standpipe through the valve M, thus allowing the water level to rise in the standpipe. After the water level has risen the desired amount about three feet, the air was shut off and the same operations were repeated as described above. This was continued until the water level reached the top of the standpipe. These calibrations were run at three different intervals of pressure, namely 55-45, 75-65, and 100-90. The data for this work and the curves obtained are shown on data sheets Nos. 2, 3, and 4 and Plates 3, 4, and 5.

The Action Of The Grinnell Alarm Valve.

From a study of the curves it may be seen that the flexibility of the stand-pipe decreases as the air entrapped in the standpipe decreases. Due to the relative rate with which these variables decrease, the resultant curves follow somewhat the linesof a parabola. As would be expected the flexibility at lower pressures is higher than those at higher pressures, the water level in each case being the same.

The Action Of The Grinnell Alarm Valve.

Discussion Of Data And Curves.

The Effect Of Flexibility On The Sensitiveness.

The system was set as described on Page9. the service pressure being held constant at seventy-five pounds throughout the test. The flexibility of the system was varied by changing the head of water in the stand-pipe. Water was drawn from the system through the valve H, the amount being obtained by using the calibrated nozzles. These tests were run using four different valves, two four inch Grinnells, a four inch Rockwood, and a six inch Rockwood. The first three valves tested gave results that indicated a somewhat uniform action of the valve, but the last valve, a new four inch Grinnell, proved to be entirely different from the others. Refering to Plates 6, 8, and 9 and data sheets 5, 7, and 8 it will be seen that in the case of the four inch Grinnell, the four inch Rockwood and the six inch Rockwood; for flexibilities greater than 5.4, 4.5 and 3.2 respectively, the sensitiveness of thevvalve

is zero or an alarm may be obtained due to a leak in the system, if the system be subjected to the conditions represented by these figures. As the flexibilities are diminished the sensitiveness of the valve rises rapidly to a maximum and on further decrease falls again rapidly. It does not however again reach zero.

Effect Of Service Pressure On Retarding Factor.

In endeavoring to study the effect that the service pressure of the system has on the action of the alarm valve, since the air content of the system must be kept constant, our flexibility curves at the different intervals are useless except as a starting point. Therefore the system was set at a Flexibility of 7.0 and the pressure then pumped up to 125 pounds. The water was then drawn off four gallons at a time and the pressure read after each withdrawal. In this way the curve shown on Plate 10. was obtained. From this curve the flexibility for any ten

pound interval may be obtained by reading from the curve the number of gallons that must be drawn off to obtain that decrease in pressure.

A series of tests were run, setting the system at various flexibilities to start with and then pumping the pressure up to 120 pounds. The service pressure was then decreased by suitable intervals and observations of retarding factor were obtained at each step. See Data Sheets 10, 11, 12, and 13 and Plates 11, 12, 13 and 14.
From the data obtained a series of curves was plotted all of which resemble each other in their general characteristics. In all cases as the service pressure is decreased the retarding factor increases until after a certain point is reached the factor reaches infinity and no alarm occurs. This point was in all cases under forty pounds pressure. The sharp bends in the curves are explained as follows:-
When the service pressure is at 120 pounds it requires but one snap of the check valve to allow enough water

to enter the retarding chamber to actuate the alarm mechanism. As the pressure is decreases the rush of water is slower but still a sufficient amount reaches the chamber to cause an alarm, the retarding factor is however increased due to the lower velocity of the water. This continues until the amount of water entering the chamber on one snap is not sufficient to cause an alarm, but since all the water does not drain from the chamber before the second snap comes the water entering the chamber together with that which remained from the first snap is sufficient to cause an alarm. In this case the time elapsing between snaps enters into the retarding factor and causes a sudden increase in that quantity. This sudden increses in the factor will be found in each case where the time of an alarm differs by one snap. As the pressure is decreased to such an extent that a considerable number of snaps are required to give an alarm, this sudden increase is not so apparent, as a very small decrease in pressure gives a large increase in retarding factor.

The Action Of The Grinnell Alarm Valve.

Effect Of Rate Of Flow On Retarding Factor.

The system is set in each case as described on Page 9, and the service pressureiis maintained at 75 pounds throughout the tests. A series of tests were run at different flexibilities varying from 8.8 to 1.3. After the system was set the water was drawn through the valve, the rate of flow being noted by means of the set of calibrated nozzles. The retarding factor was noted for each different rate of flow. The rates of flow were varied from the minimum flow which would give an alarm to the maximum flow attainable. The results of the tests are shown on Data Sheets Nos. 14, 15, 16, 17, 18, 19, and 20; and on Plates 15, 16, 17, 18, 19, 20, and 21. For flexibilities greater than 5.4 the rate of flow has no effect on the retarding factor and it is constant, also an alarm is obtained on one snap. Refering to Plate 6. it will be seen that for these flexibilities an alarm may be obtained on a leak in the system or

the sensitiveness of the valve is zero. For flexibilities less than 5.4 or within the arch of the curve on Plate 6, the rate of flow, however has a marked effect on the retarding factor. In the case of smaller flexibilities the retarding factor is constant when the alarm takes place on one snap, but when the rate of flow is decreased to such an extent that it requires more than one snap to give an alarm, the retarding factor is increased suddenly, causing the sharp bends noticed in the curves on the above mentioned plates. Also from Plate 6 it will be noticed that as the flow is decreased further no alarm results. These points checked out in the retarding factor tests and as a result at the point where there was no alarm the retarding factor is infinity.

Effect Of Flexibility On The Retarding Factor.

The system was set as described on Page 9, and the service pressure was maintained at seventy-five

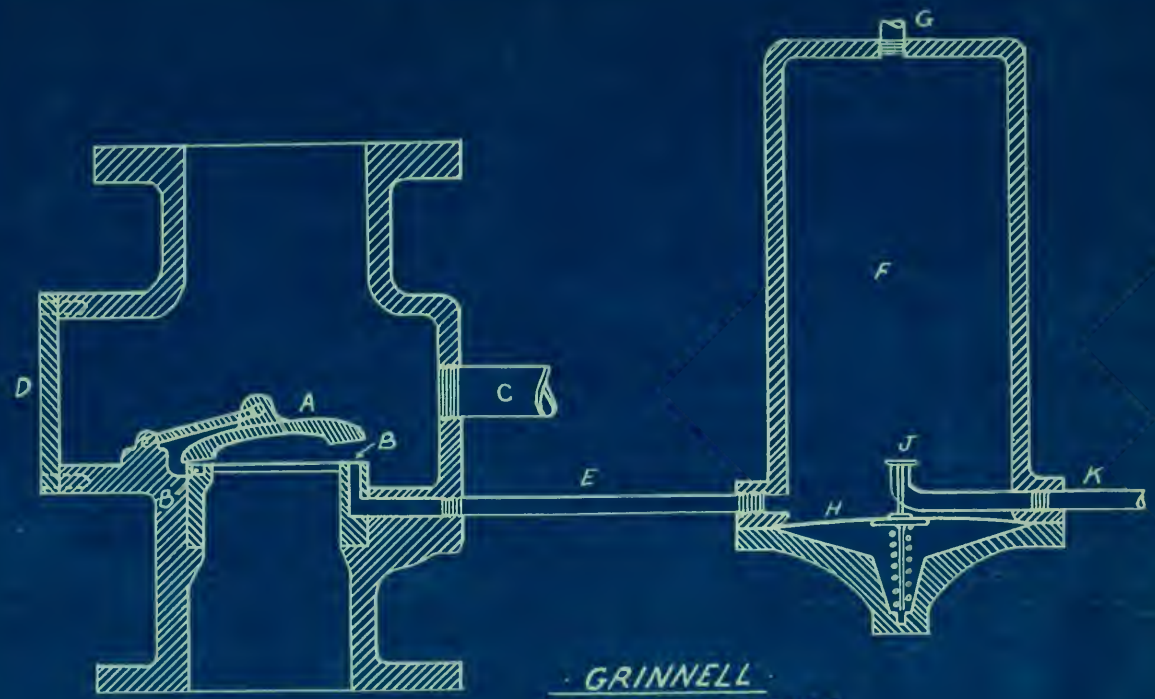
pounds. The rate at which the water was drawn off was constant at twenty-five gallons per. minute. The flexibility of the system was varied from 5.5 to 1.1 and the retarding factor was noted for each step. The results of these tests are shownoon Data Sheets Nos. 21, 22, 23 and Plates 22, 23 and 24.

As long as the flexibilities are large enough so that an alarm is caused on one snap of the check valve, the retarding factor is constant. As the flexibility is decreased it requires twomsnaps for the alarm and at this point there is a sharp rise in the retarding factor and a corresponding sharp bend in the curve. The sudden increase occurs at each point where the valve requires one more snap of the clapper in order to give an alarm.

The Differential Action Of The Valve.

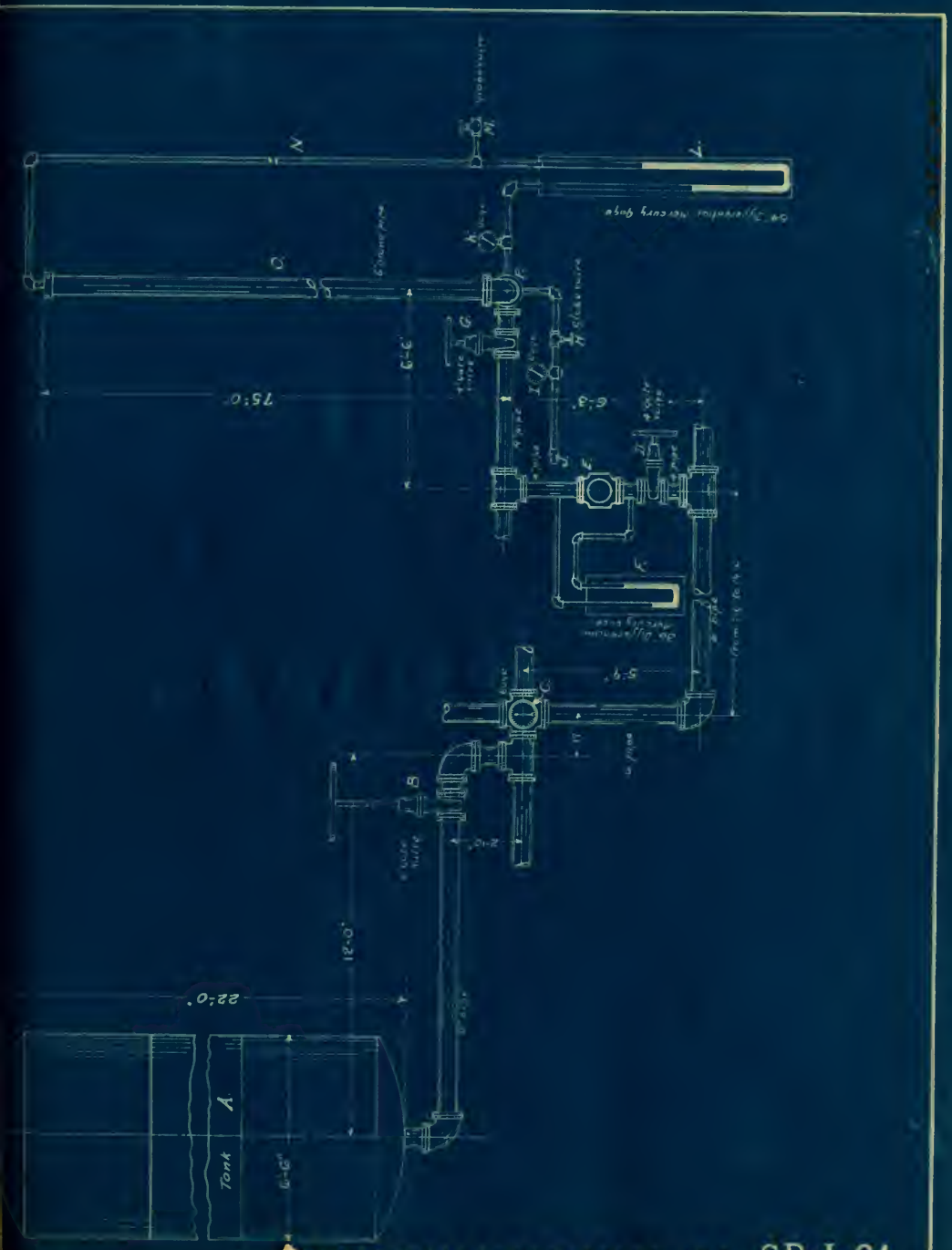
The system was set as described on Page9, and the service pressure pumped to 120 pounds. Water was then drawn off slowly and the mercury gauge

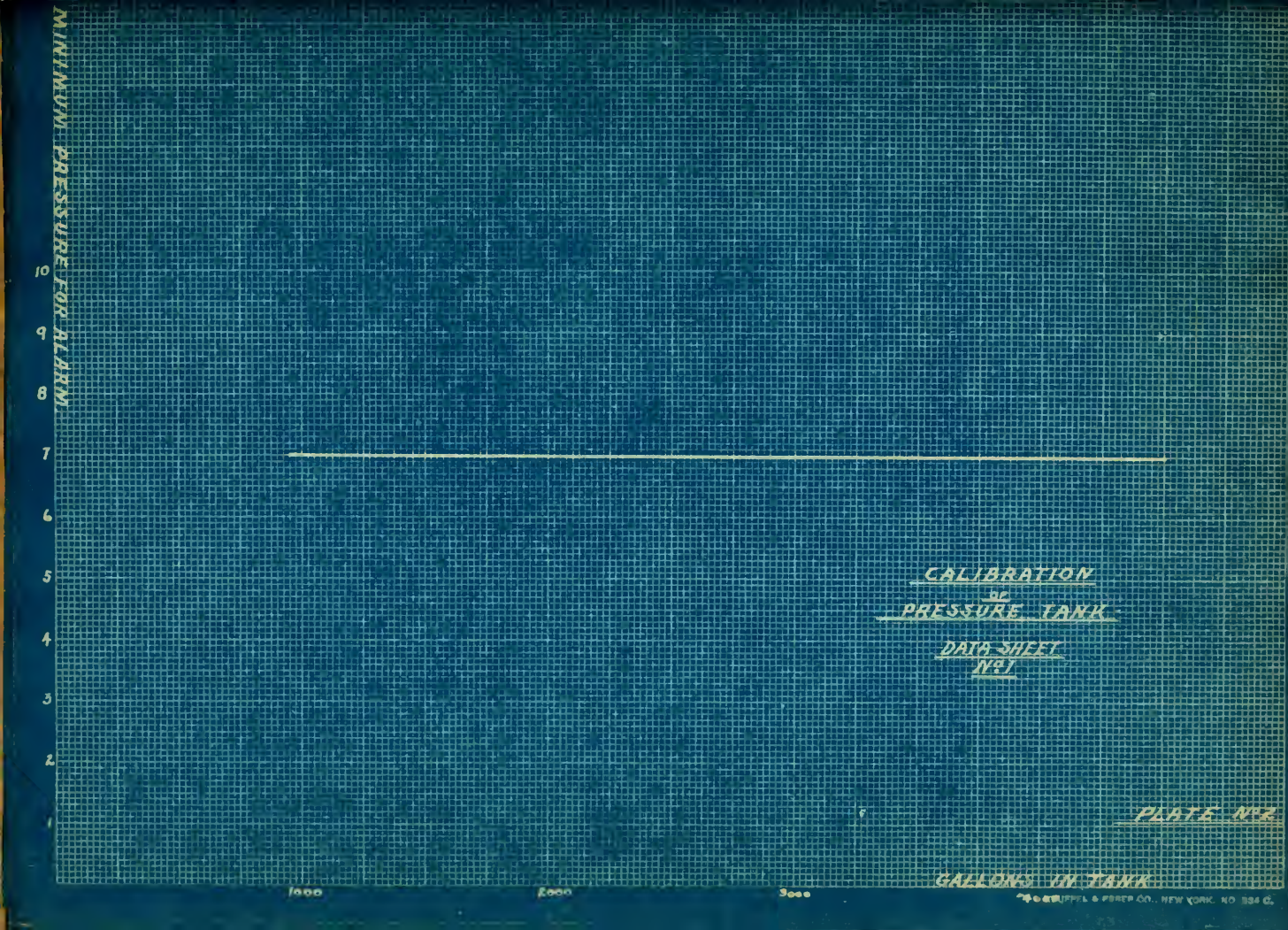
connected to the valve was read just as the valve tripped. This reading gives directly the difference in head in inches of mercury necessary to cause the valve to trip at that particular service pressure. The pressure was then decreased by suitable steps and the process repeated at each step. Data Sheet No. 24 and Plate 25 show the results of this test. From the Curve on Plate 25 it will be seen that as the service pressure decreases the differential also decreases. The relative rates of decrease are such that the curve takes the lines of a parabola.

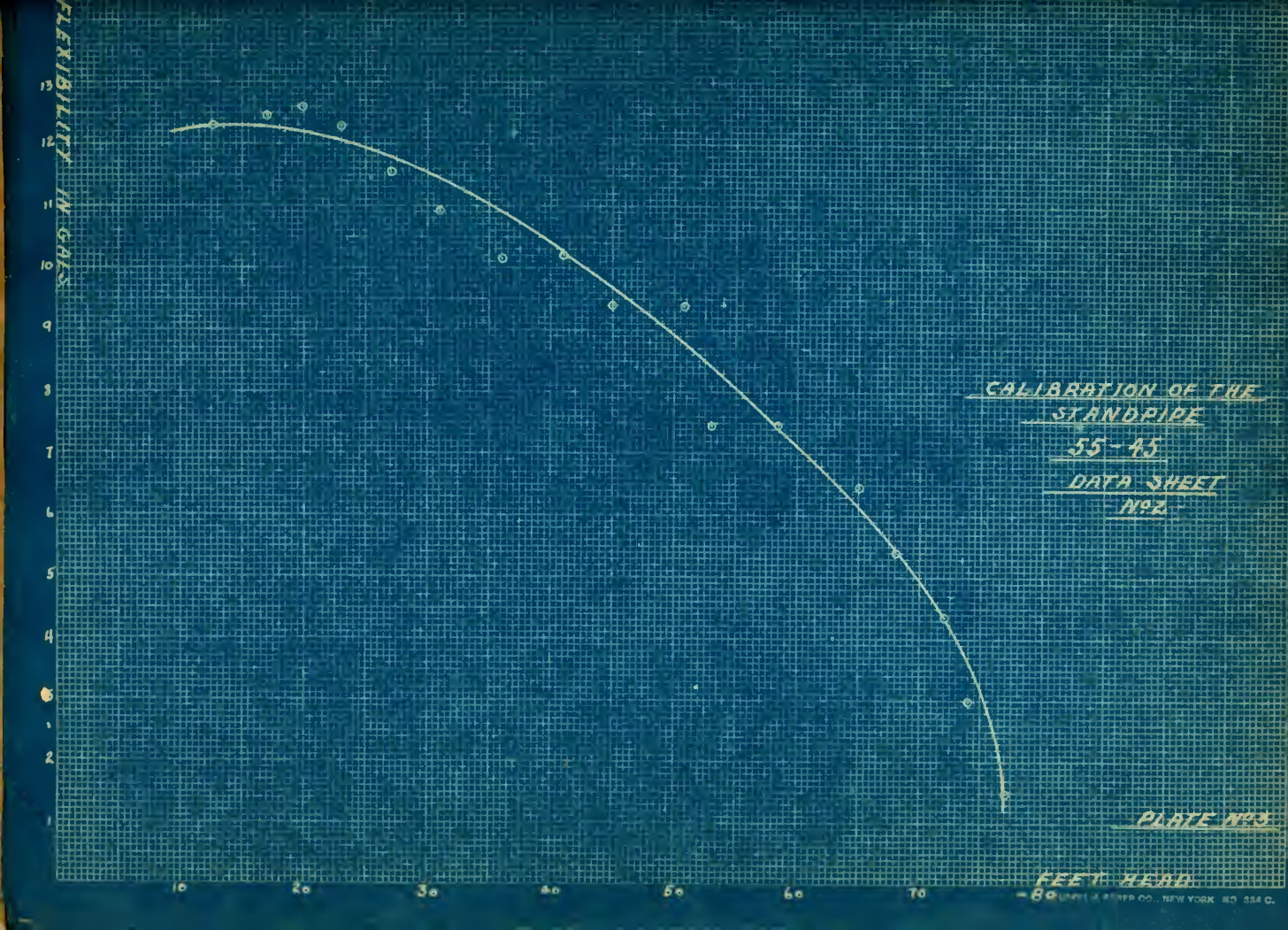


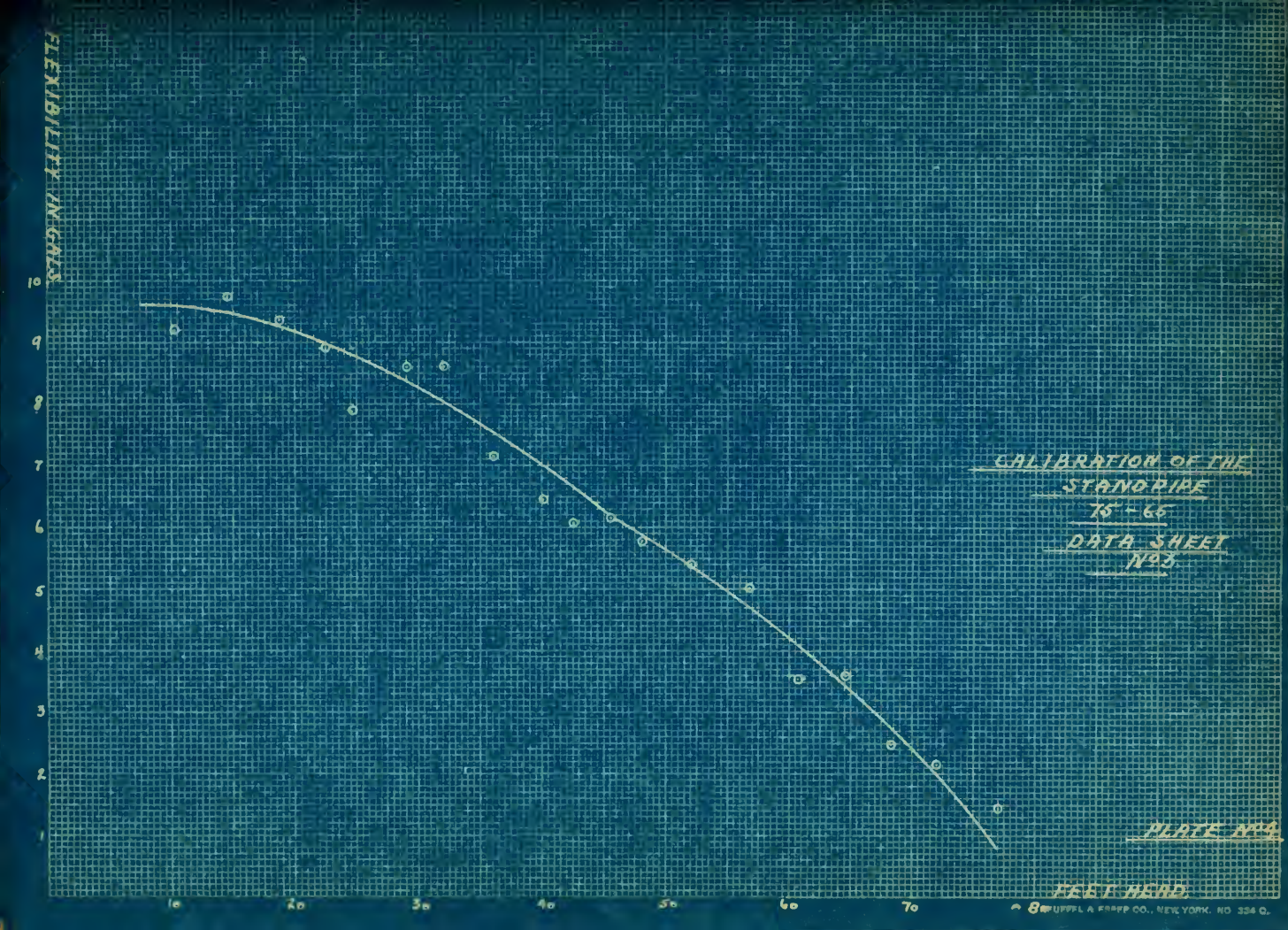
GRINNELL
VARIABLE PRESSURE
ALARM VALVE.

PLATE A

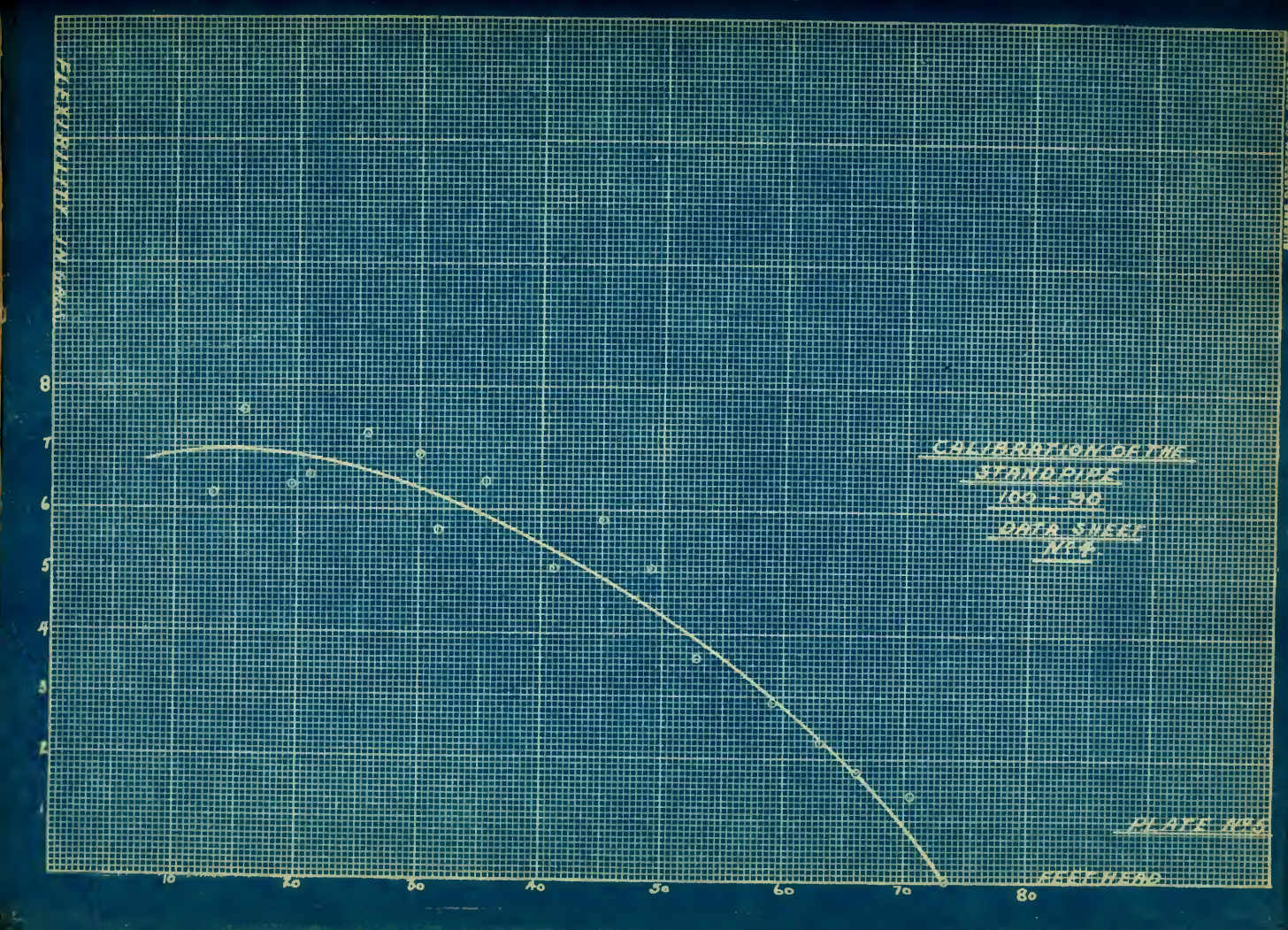

75'-0"
6'-3"
5'-9"
22'-0"
12'-0"
Tank A

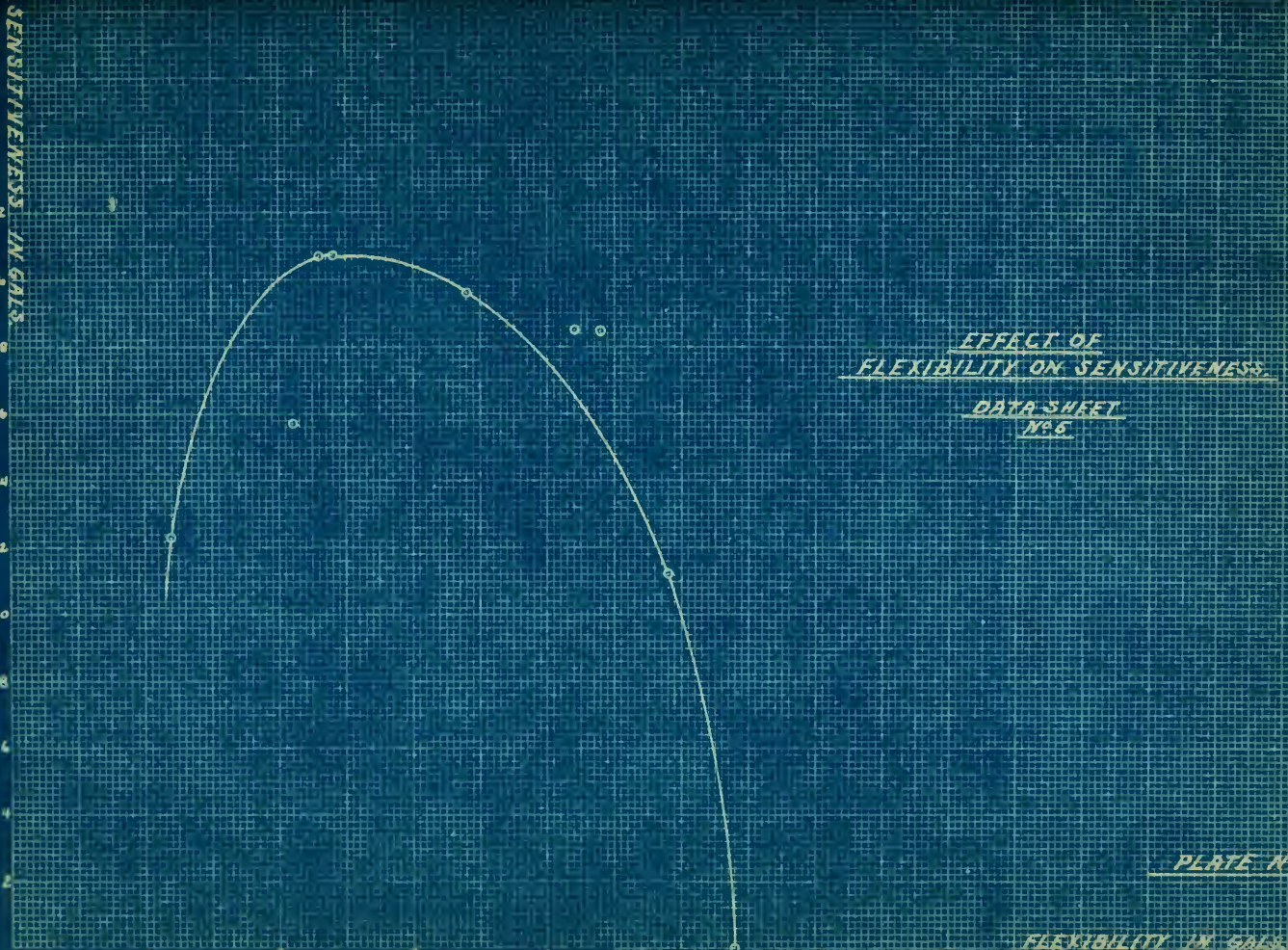

MINIMUM PRESSURE FOR ALARM
10
9
8
7
6
5
4
3
2
1
1000
2000
3000
CALIBRATION
OF
PRESSURE TANK
DATA SHEET
No 1
PLATE No 2
GALLONS IN TANK
KEUFFEL & ESSER CO., NEW YORK. NO. 334 C.


FLEXIBILITY IN CMS.
13
12
11
10
9
8
7
6
5
4
3
2
1
10
20
30
40
50
60
70
80
FEET HEAD.
CALIBRATION OF THE STANDPIPE
55 - 45
DATA SHEET No. 2
PLATE No. 3



8 KUFFEL & ESSER CO., NEW YORK. NO 334 Q.


CALIBRATION OF THE
STAND PIPE
100 - 90
DATA SHEET
No. 4
PLATE No. 2
8
7
6
5
4
3
2
1
10
20
30
40
50
60
70
80

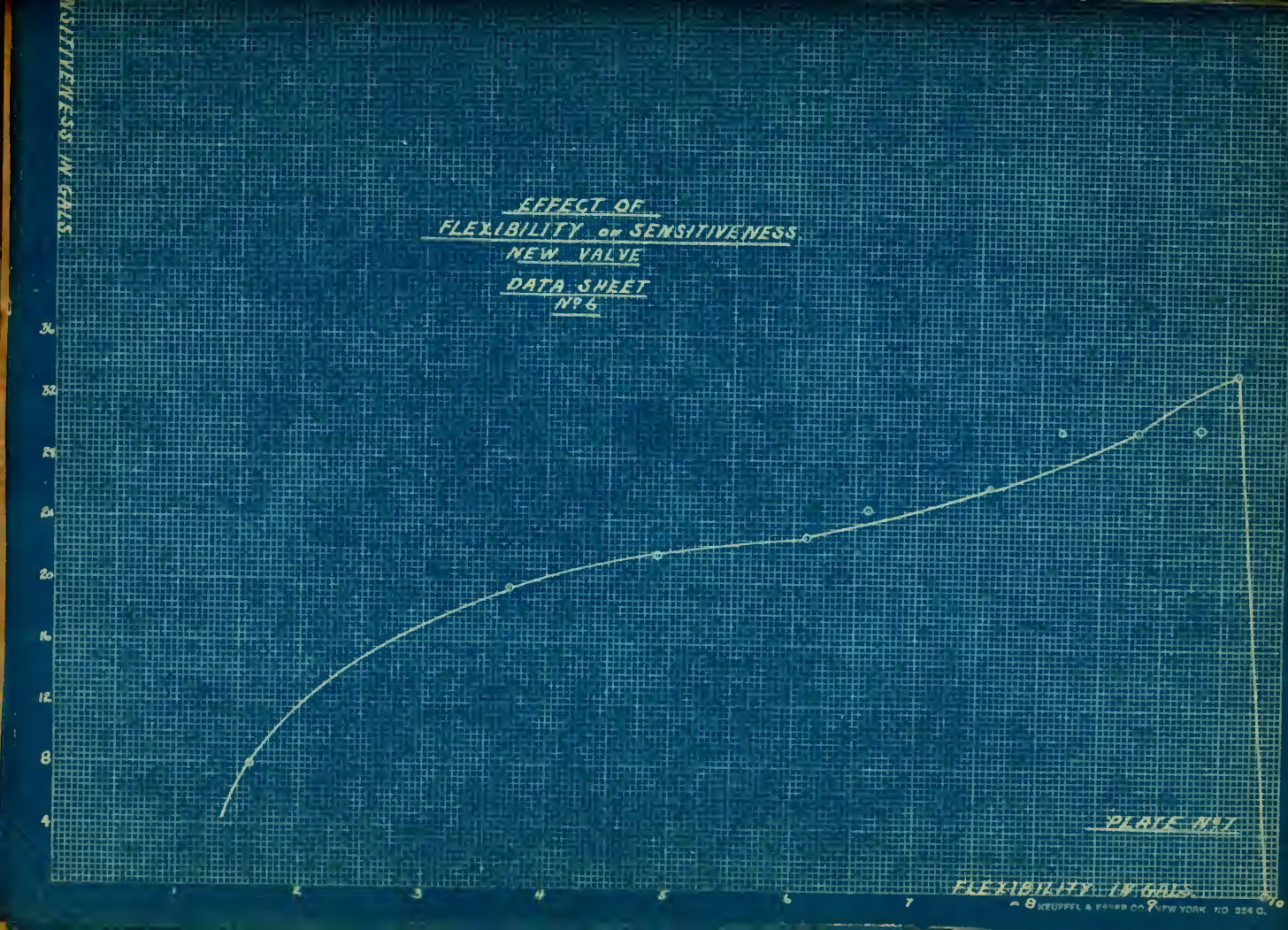


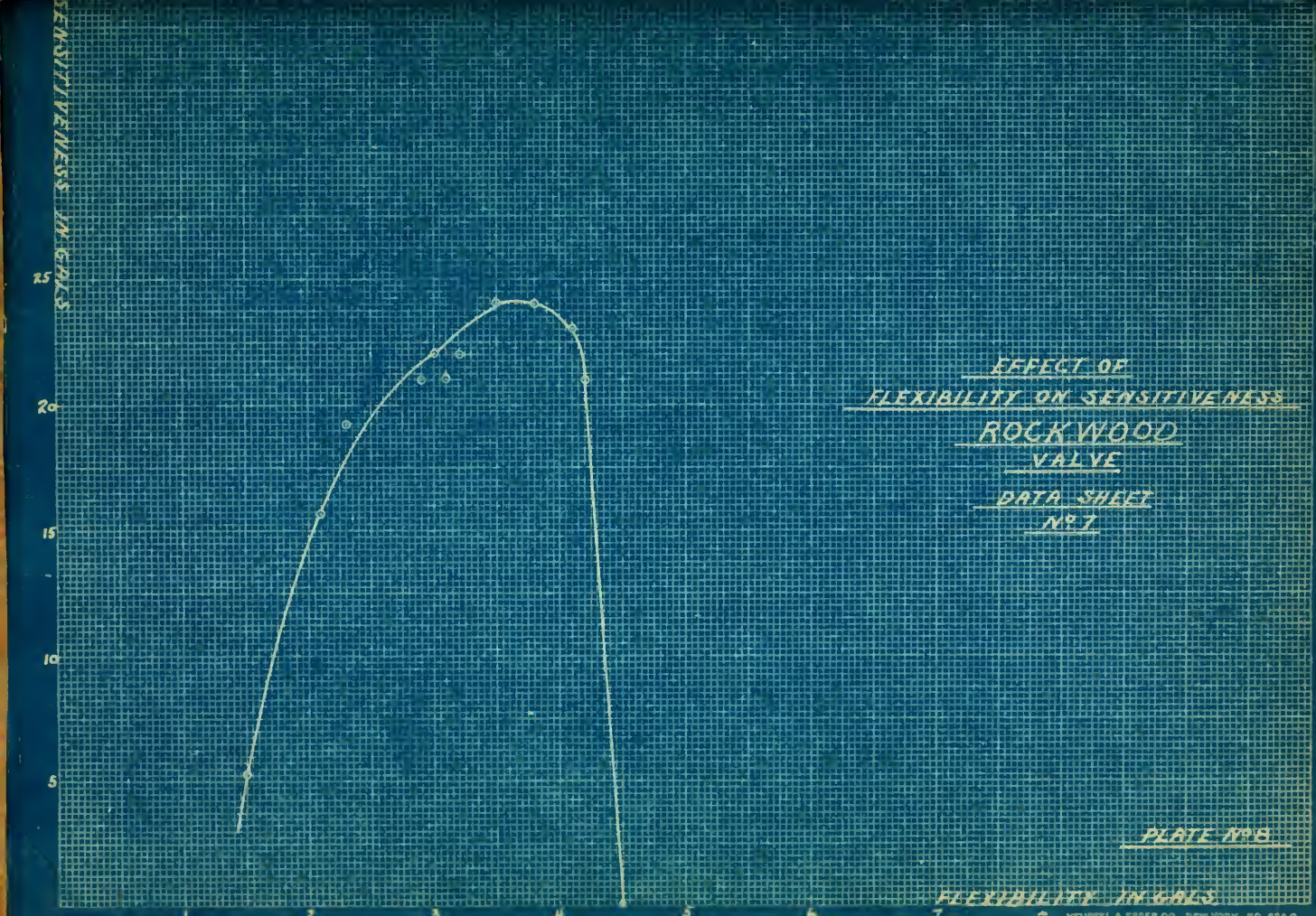
EFFECT OF
FLEXIBILITY ON SENSITIVENESS.

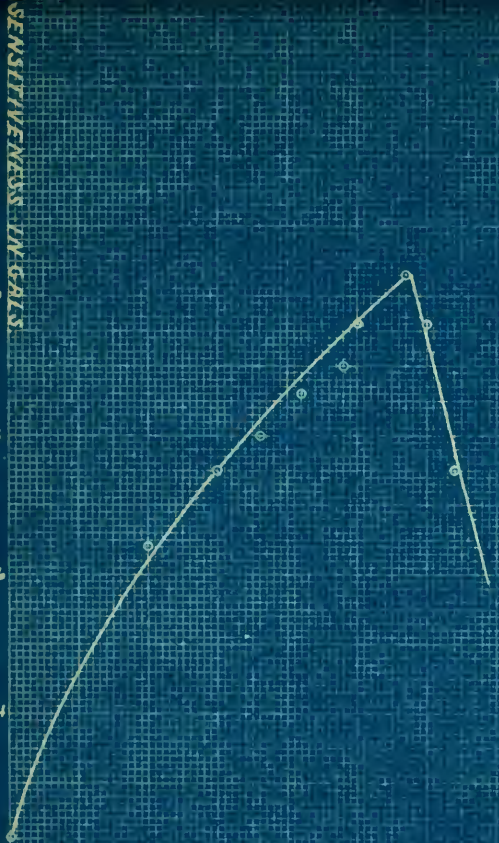
DATA SHEET
No. 6.

PLATE No. 6.

KEUFFEL & ESSER CO., NEW YORK. NO. 324 G.


EFFECT OF
FLEXIBILITY or SENSITIVENESS.
NEW VALVE
DATA SHEET
No 4
SENSITIVENESS IN GALS.
34
32
28
24
20
16
12
8
4
1
2
3
4
5
6
7
8
FLEXIBILITY IN GALS.
PLATE No 1.
KEUFFEL & ESSER CO. NEW YORK NO 324 C.


SENSITIVENESS IN INCHES
25
20
15
10
5
1
2
3
4
5
6
7
EFFECT OF
FLEXIBILITY ON SENSITIVENESS
ROCKWOOD
VALVE
DATA SHEET
No 1
PLATE XXII
FLEXIBILITY IN INCHES
KEUFFEL & ESSER CO., NEW YORK. NO. 334 C.

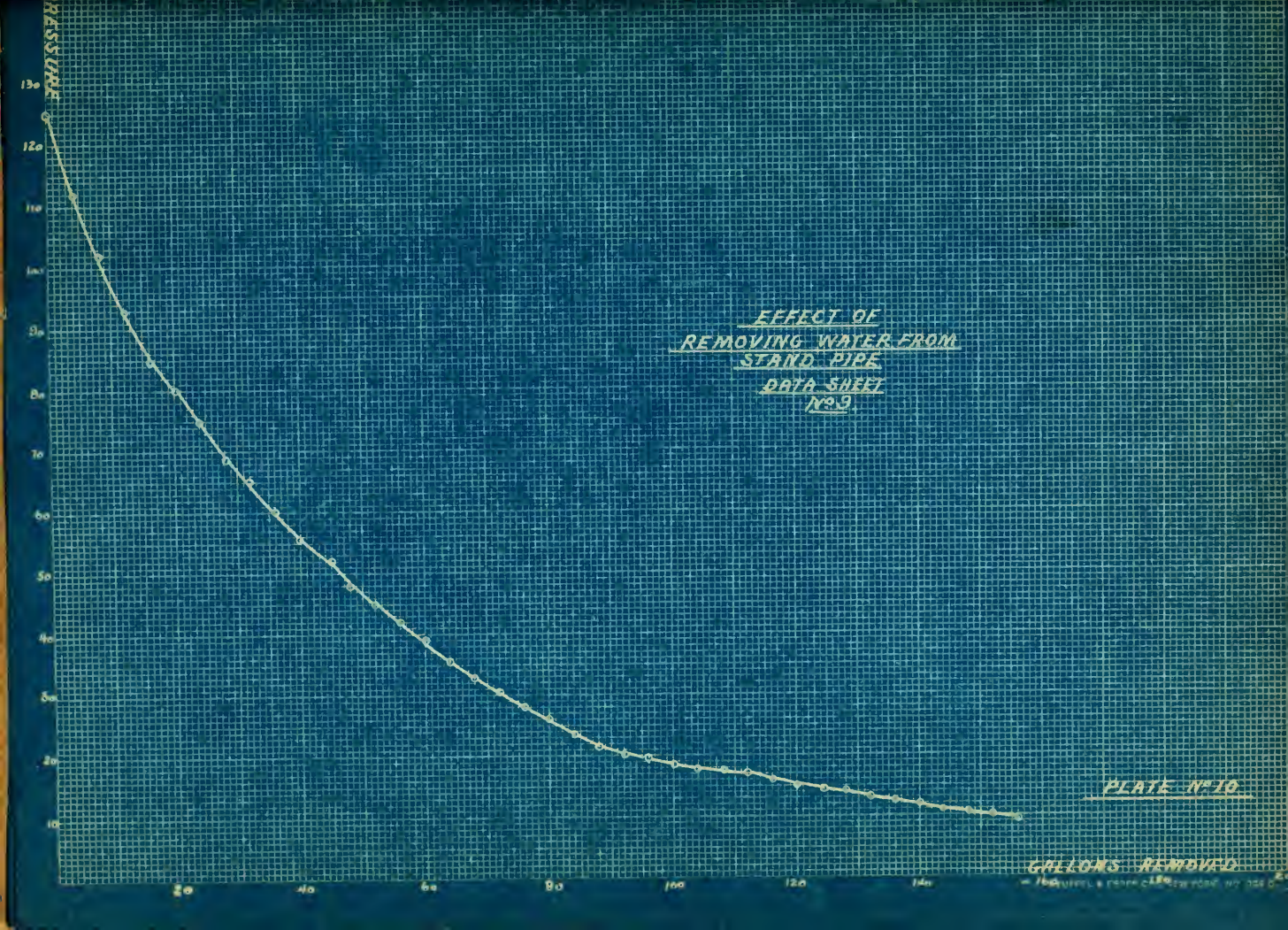


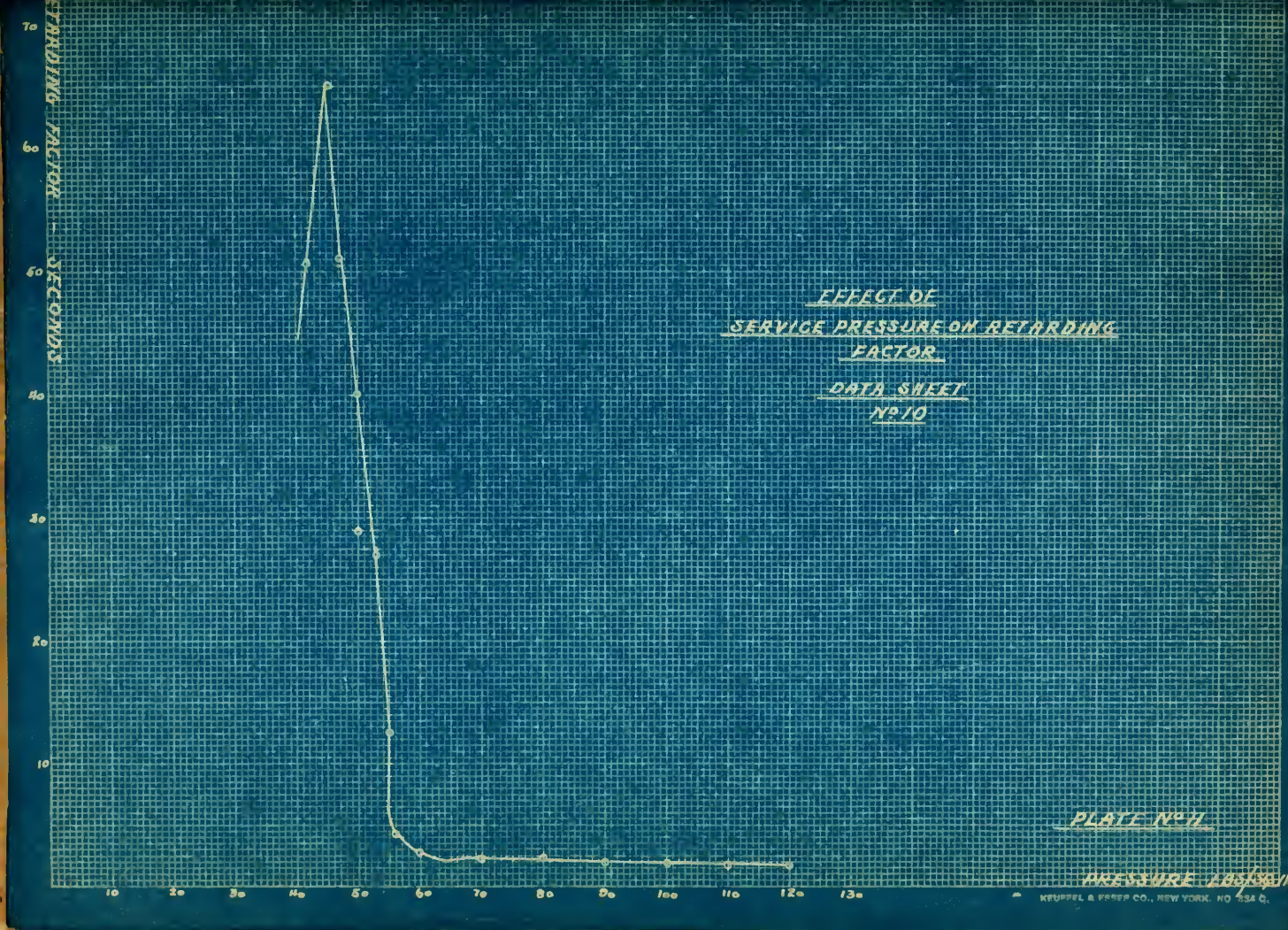
EFFECT OF
FLEXIBILITY ON SENSITIVENESS
ROCKWOOD
VALVE
DATA SHEET
No 8

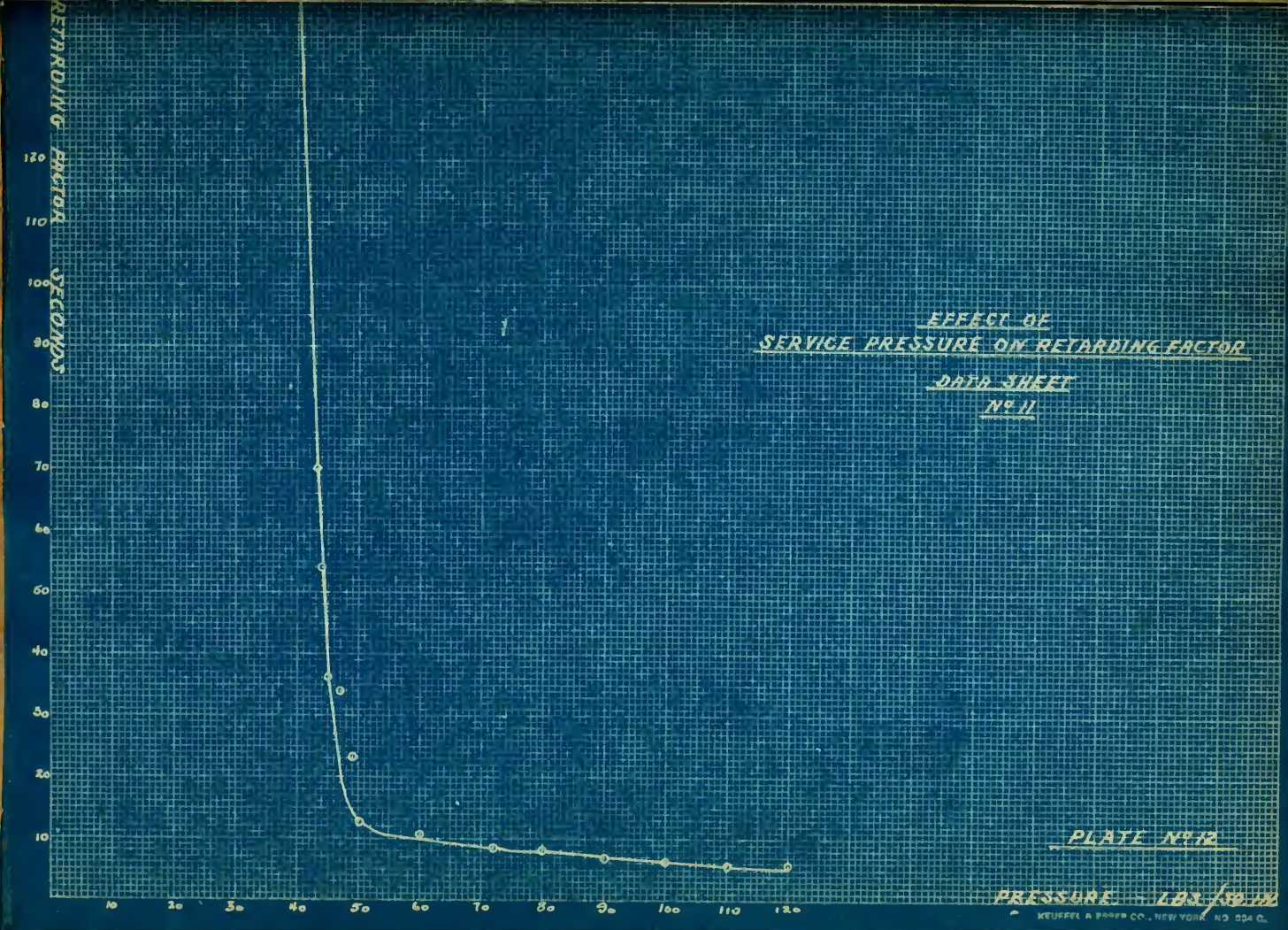
PLATE No 9

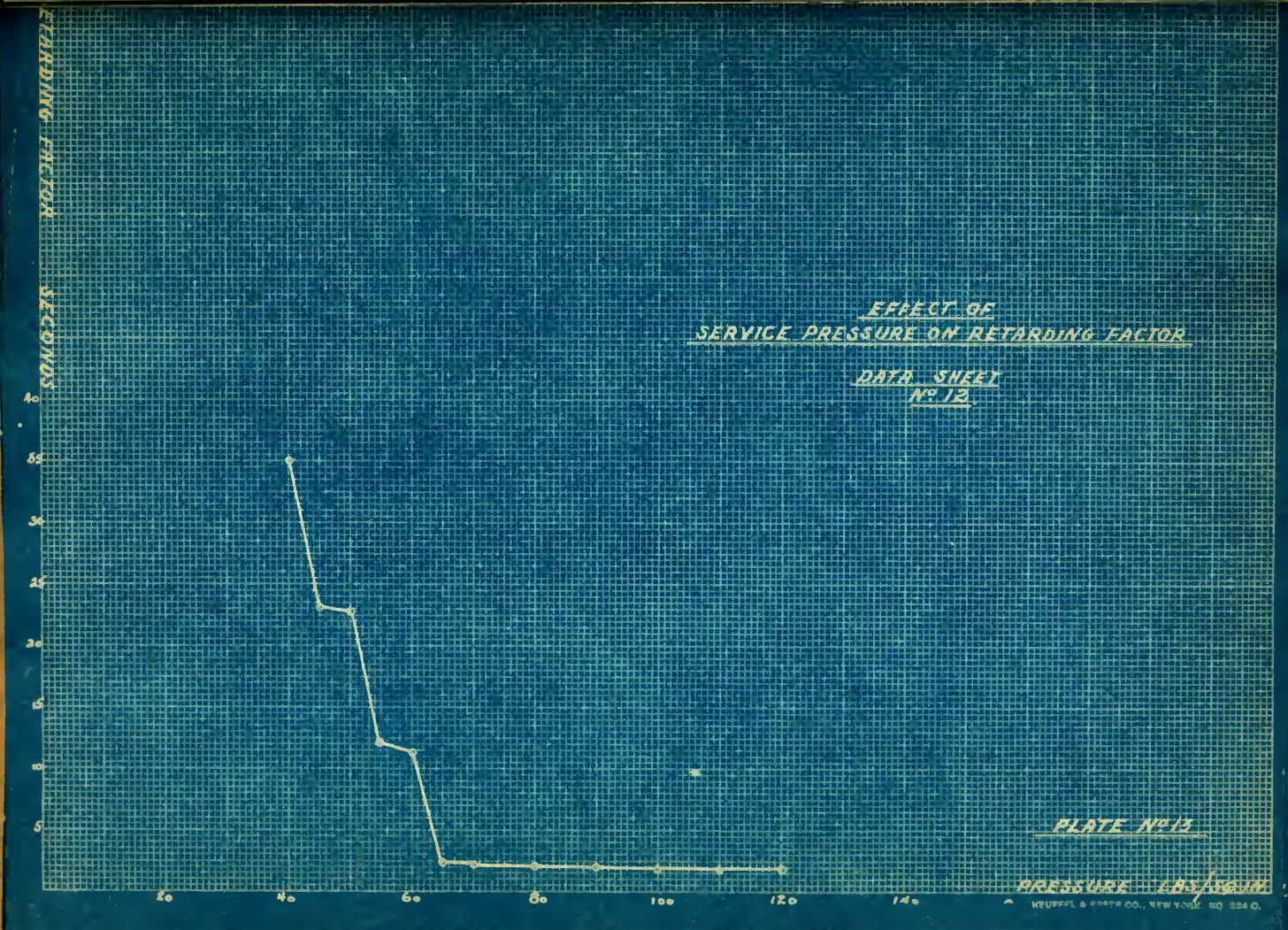
FLEXIBILITY IN GALS.

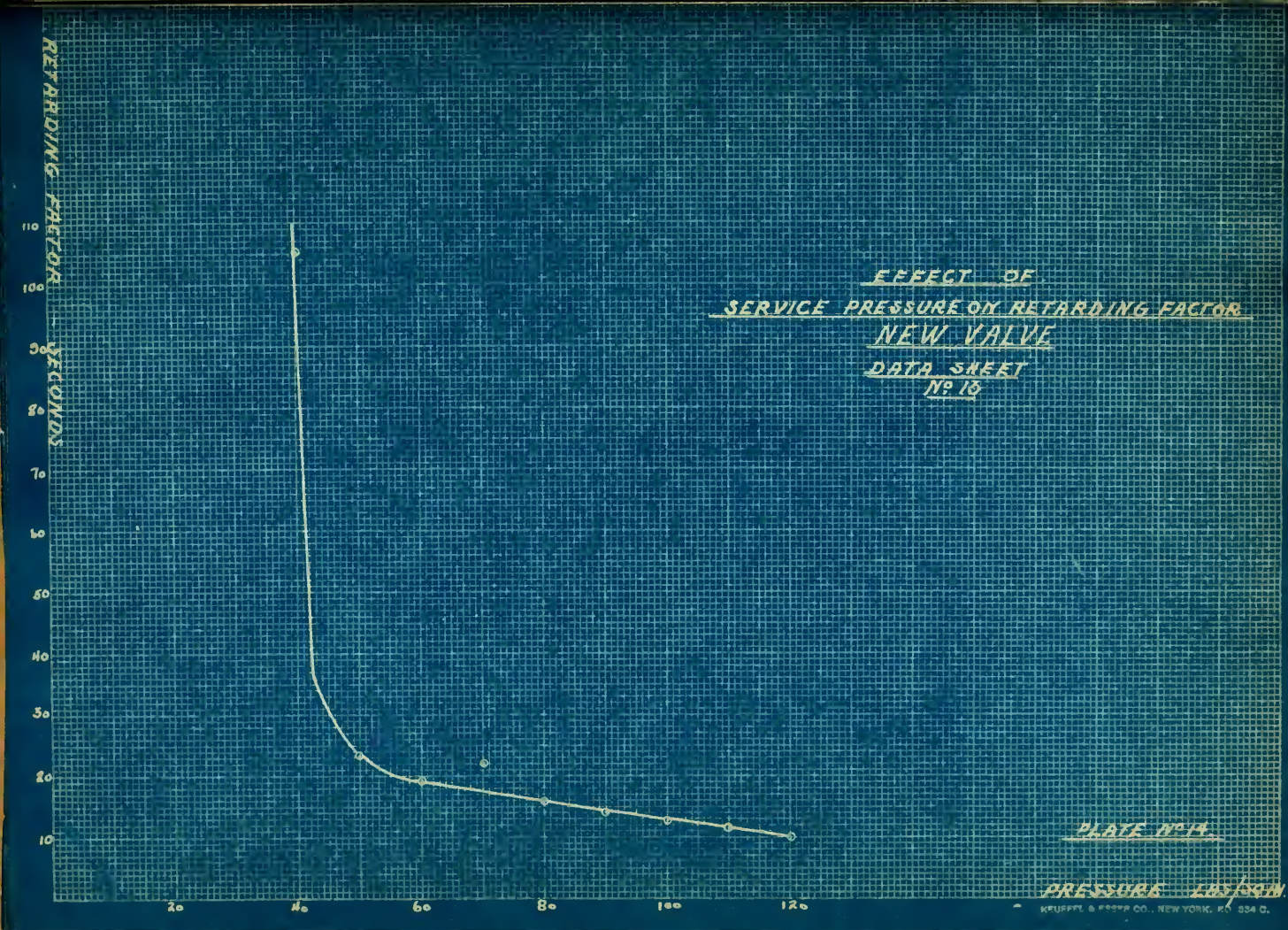
KEUFFEL & ESSER CO., NEW YORK. NO 334 C.


PRESSURE
130
120
110
100
90
80
70
60
50
40
30
20
10
EFFECT OF
REMOVING WATER FROM
STAND PIPE
DATA SHEET
No. 9
PLATE No. 10
GALLONS REMOVED
20
40
60
80
100
120
140


RETARDING FACTOR - SECONDS
70
60
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
110
120
130
EFFECT OF
SERVICE PRESSURE ON RETARDING
FACTOR.
DATA SHEET
No. 10
PLATE No. 11
PRESSURE ABS.
KEUFFEL & ESSER CO., NEW YORK. NO. 334 G.


RETARDING FACTOR SECONDS
120
110
100
90
80
70
60
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
110
120
EFFECT OF
SERVICE PRESSURE ON RETARDING FACTOR
DATA SHEET
No. 11
PLATE No. 12
PRESSURE LBS. PER SQ. IN.
KEUFFEL & ESSER CO., NEW YORK No. 324 C.


RETARDING FACTOR SECONDS
40
30
25
20
15
10
5
EFFECT OF
SERVICE PRESSURE ON RETARDING FACTOR
DATA SHEET
No. 12.
PLATE No. 12.
40
60
80
100
120
140
PRESSURE LBS. PER SQ. IN.
KEUFFEL & ESSER CO., NEW YORK. NO. 334 G.


RETARDING FACTOR SECONDS
110
100
90
80
70
60
50
40
30
20
10
20
40
60
80
100
120
EFFECT OF
SERVICE PRESSURE ON RETARDING FACTOR
NEW VALVE
DATA SHEET
No 18
PLATE No 14.
PRESSURE LBS/SQ IN.
KEUFFEL & ESSER CO., NEW YORK. NO. 334 G.

RETARDING FACTOR "R"

EFFECT OF
RATE OF FLOW ON RETARDING FACTOR

DATA SHEET
No. 14.

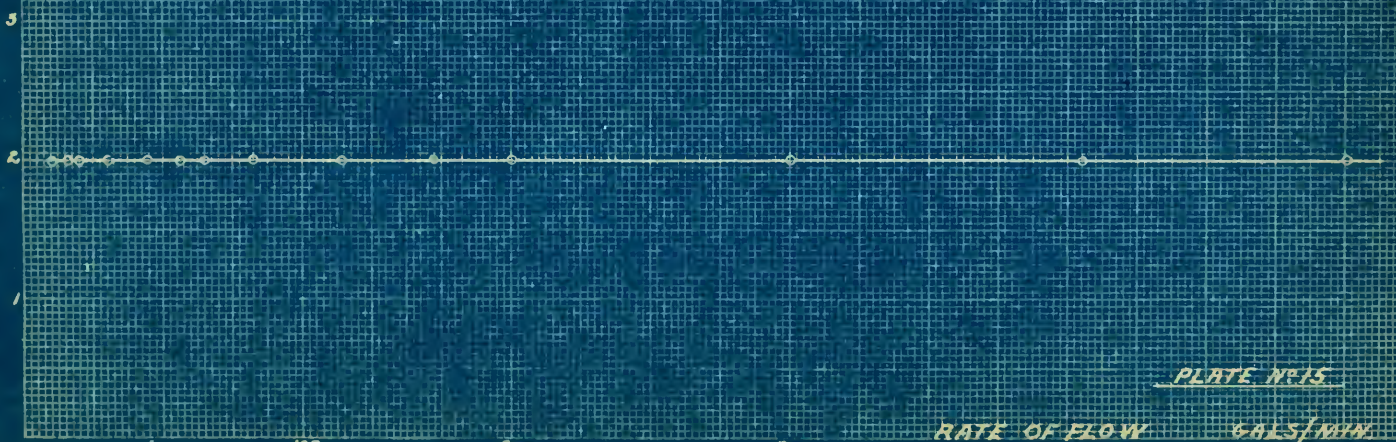
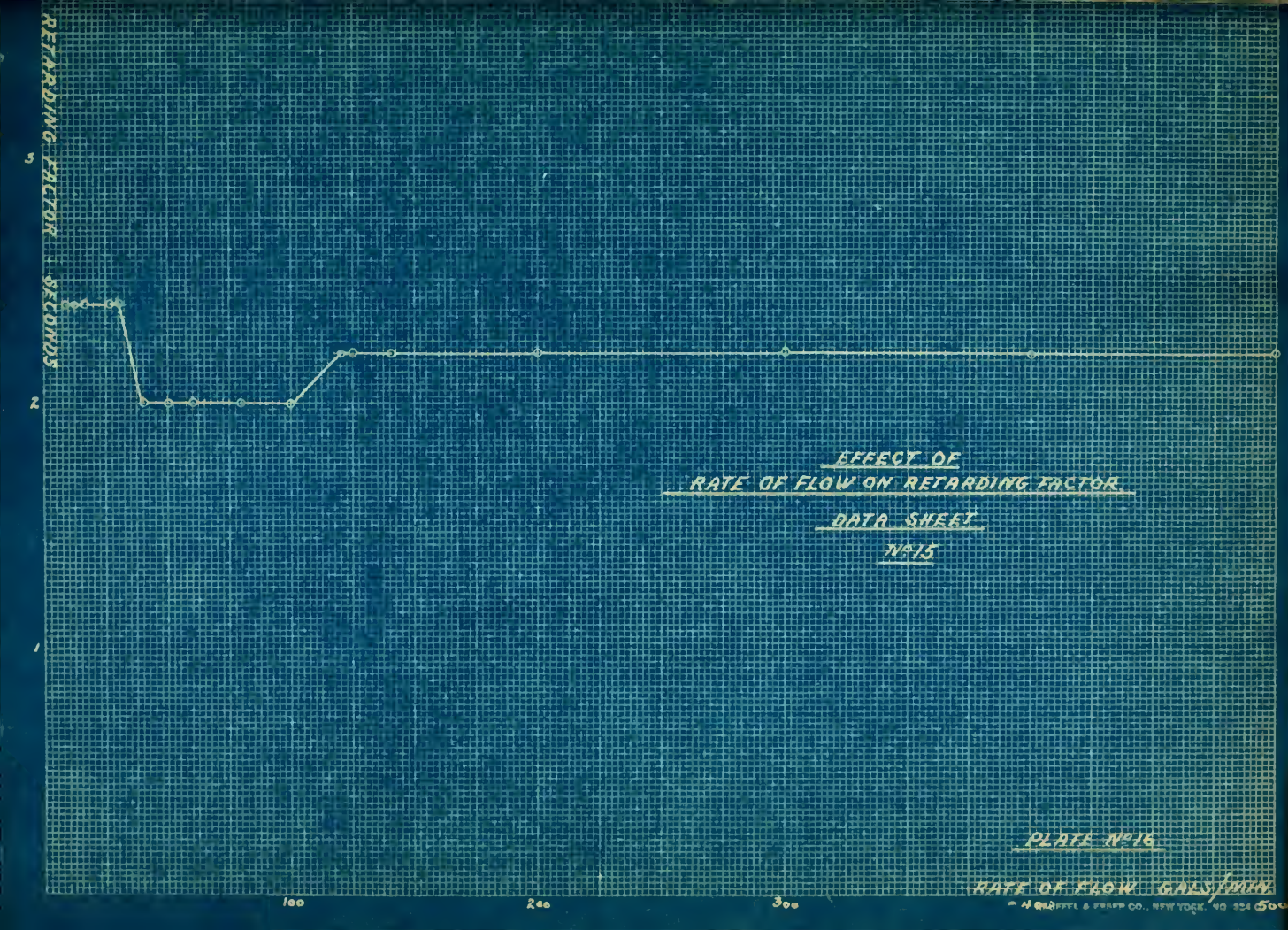
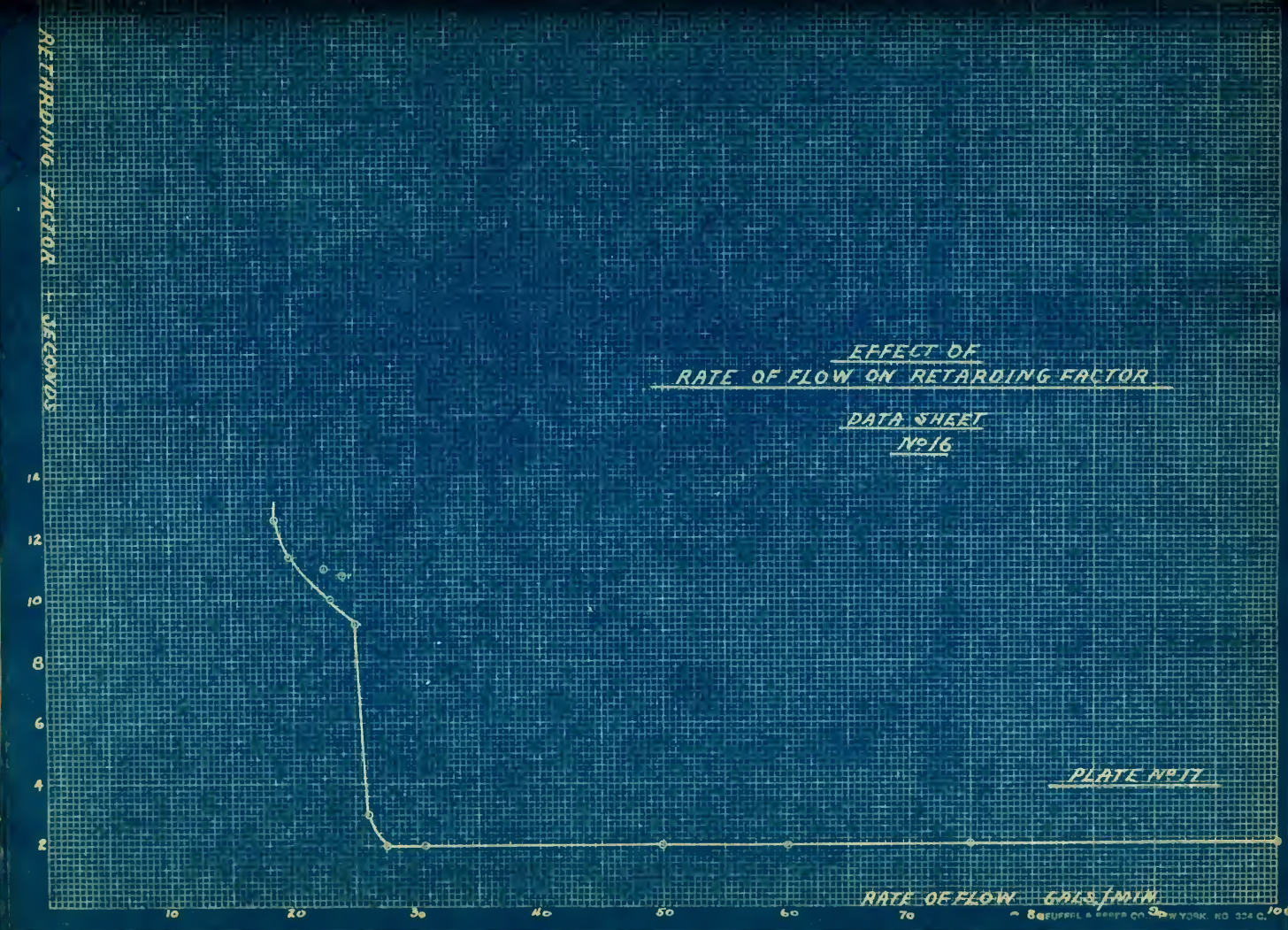


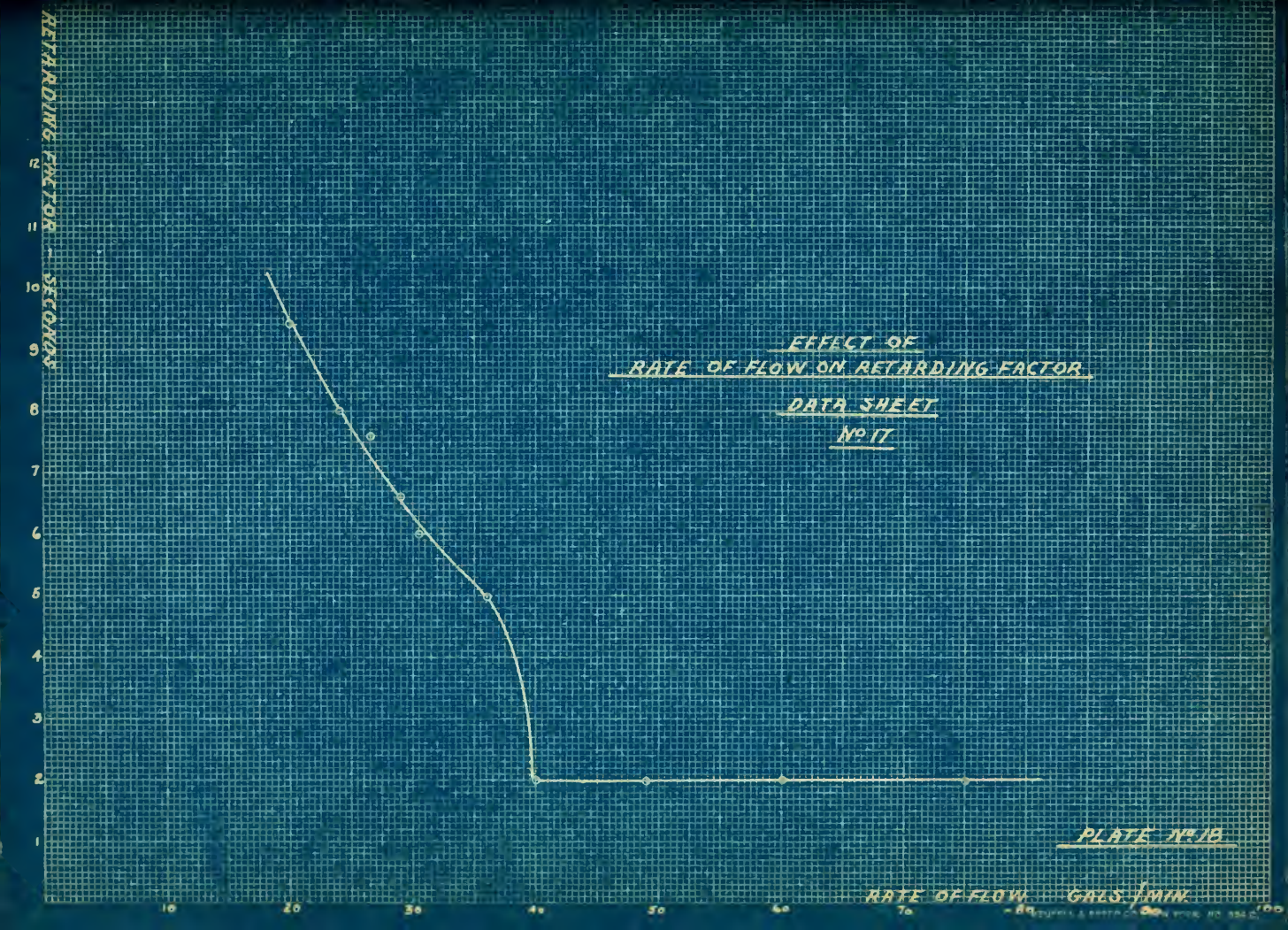
PLATE No. 15.

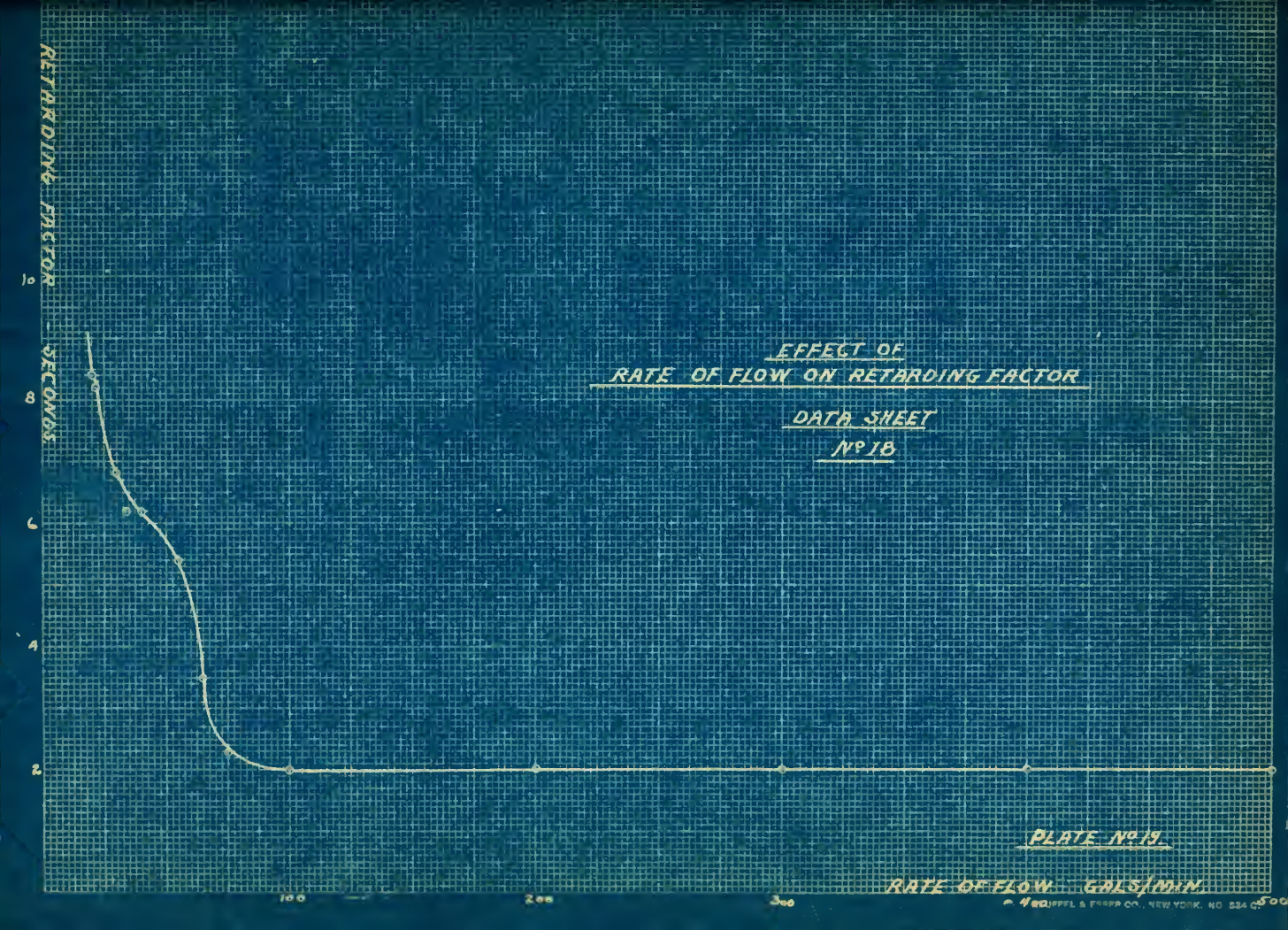
RATE OF FLOW GALS/MIN.

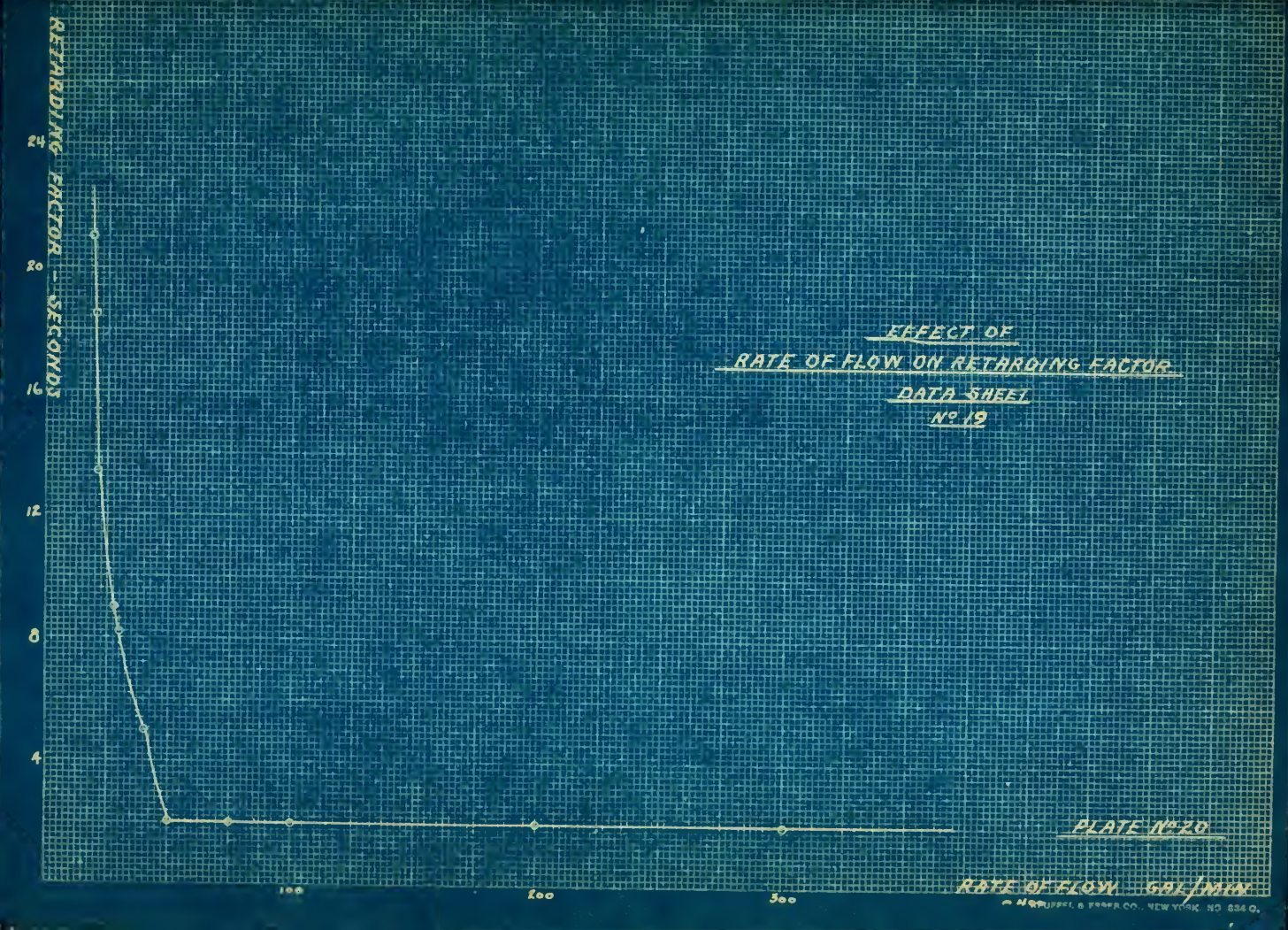
KEUFFEL & ESSER CO., NEW YORK

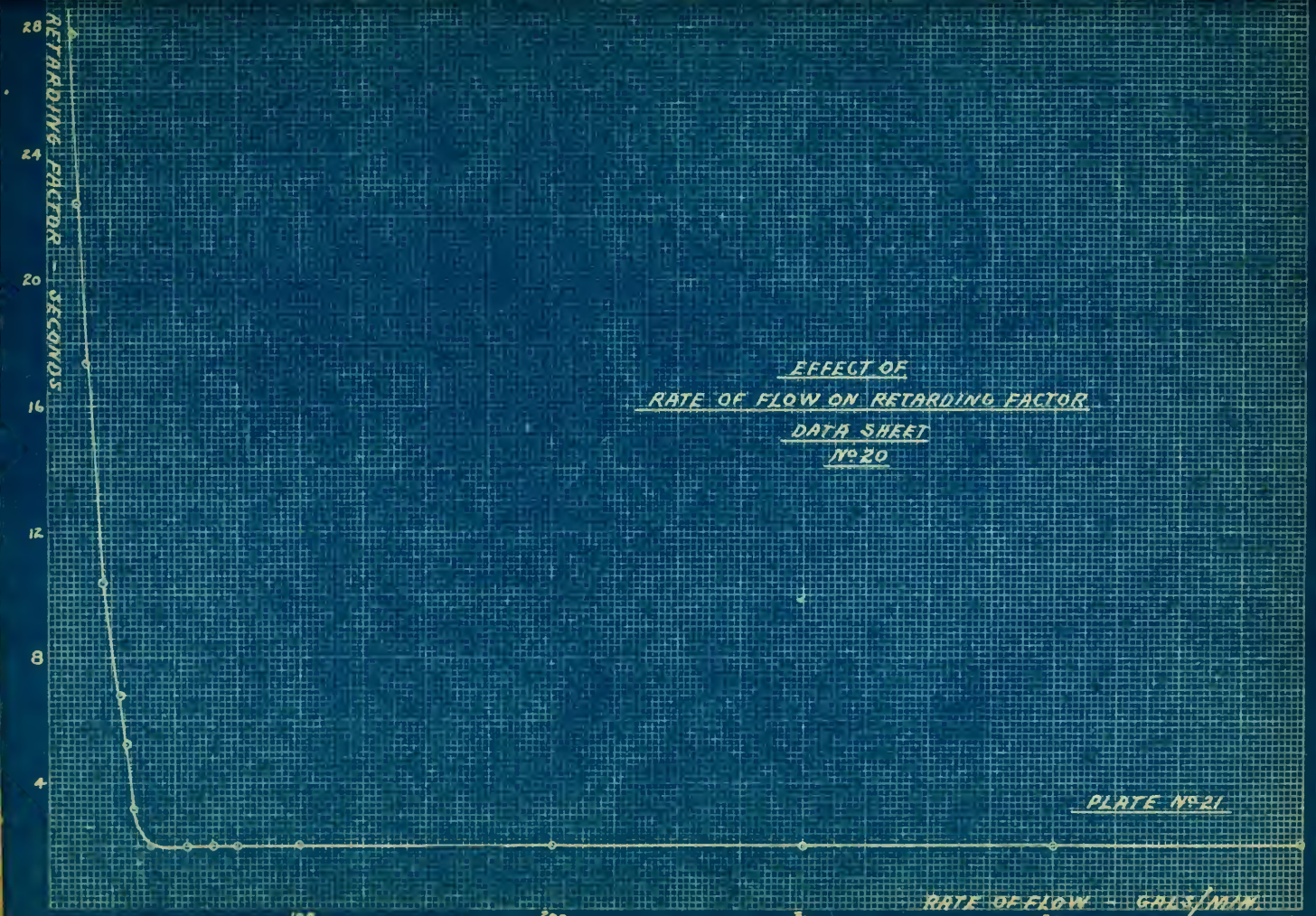

RETARDING FACTOR SECONDS
3
2
1
100
200
300
RATE OF FLOW GALS/MIN.
EFFECT OF
RATE OF FLOW ON RETARDING FACTOR.
DATA SHEET
No. 15
PLATE No. 16
H. DUFFEL & FORFP CO., NEW YORK.

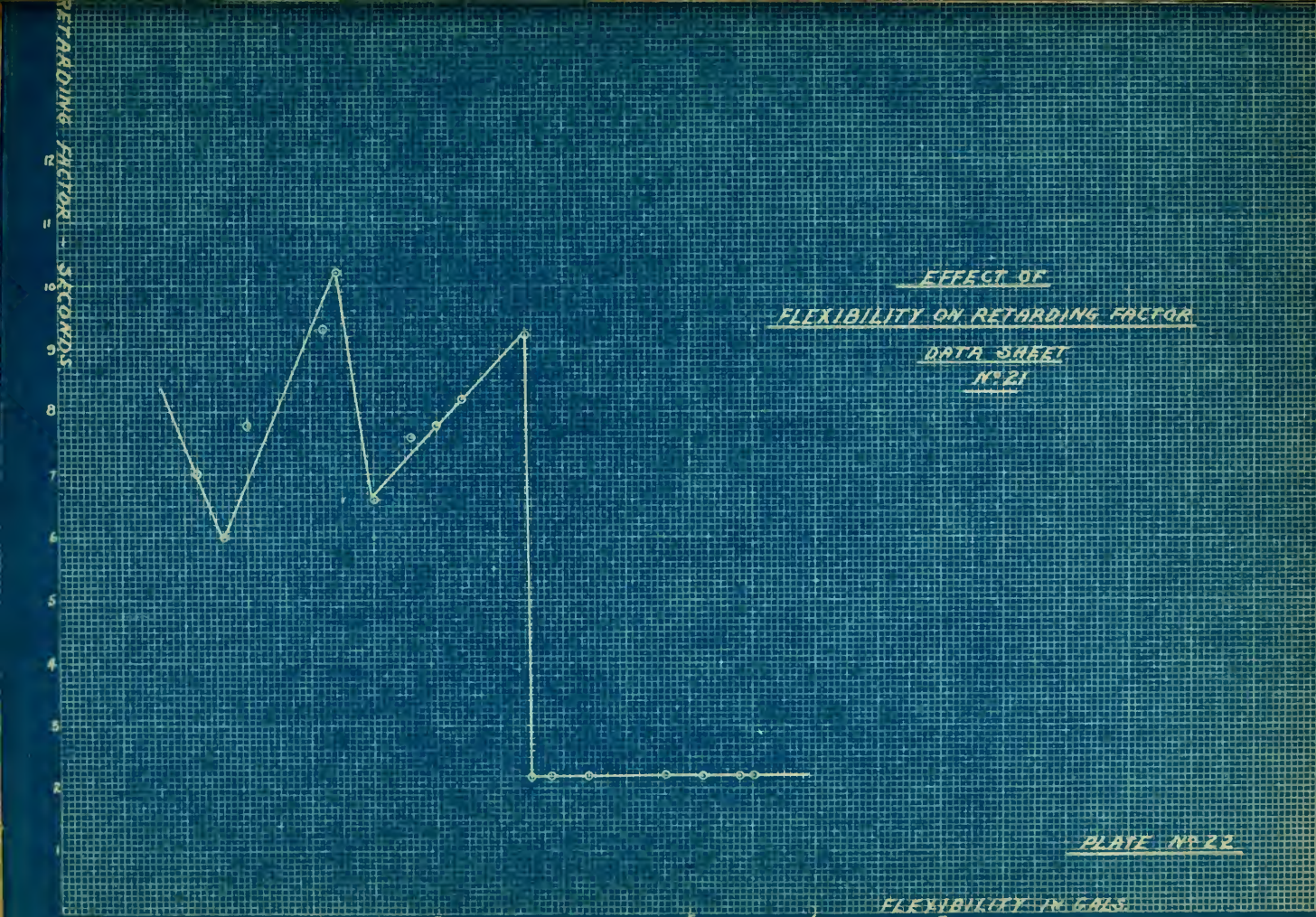

RETARDING FACTOR - SECONDS
14
12
10
8
6
4
2
10
20
30
40
50
60
70
80
90
100
RATE OF FLOW GALS./MIN.
EFFECT OF
RATE OF FLOW ON RETARDING FACTOR
DATA SHEET
No. 16
PLATE No. 17
KUFFEL & ESSER CO. NEW YORK. NO. 334 C.

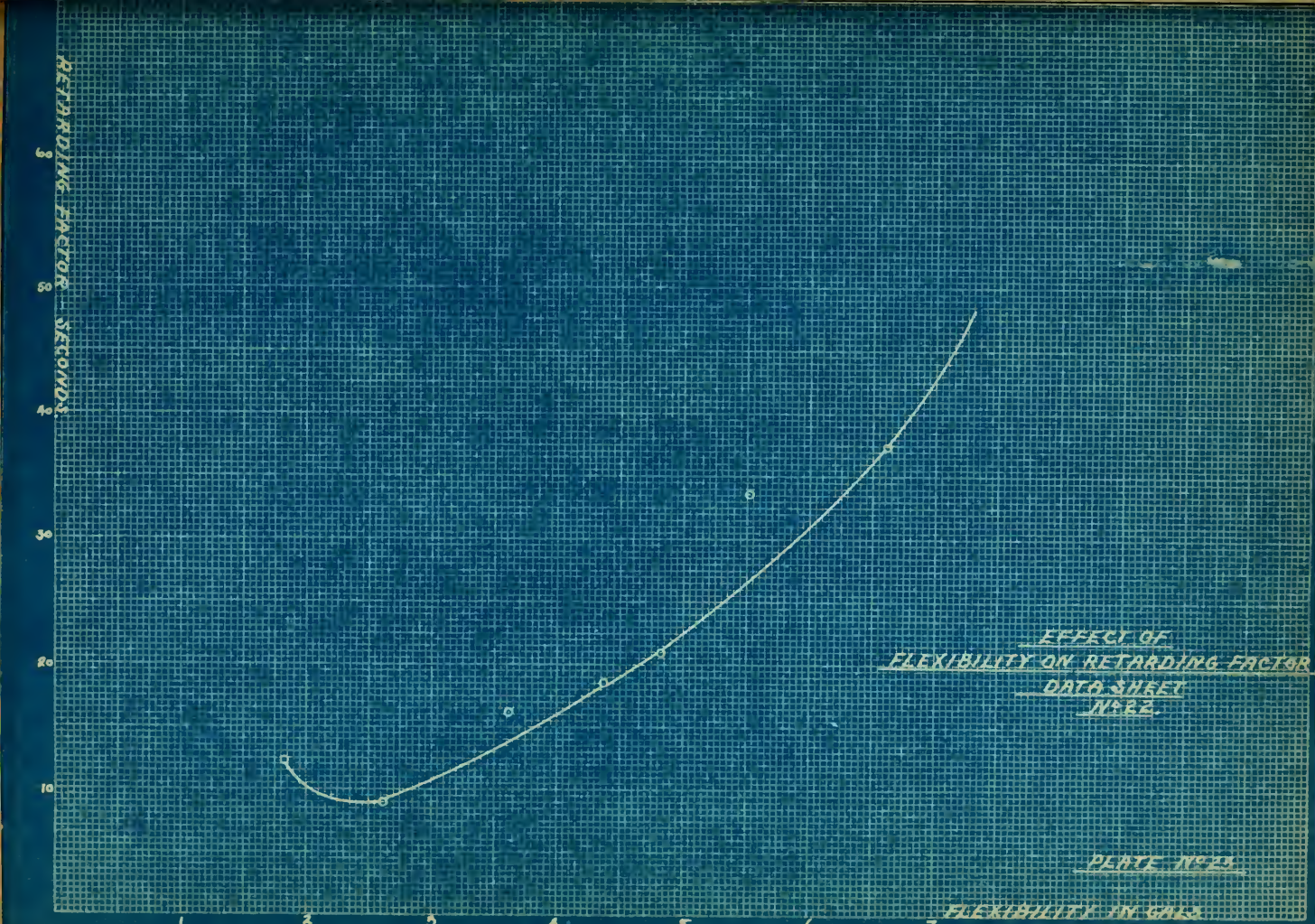

RETARDING FACTOR - SECONDS
12
11
10
9
8
7
6
5
4
3
2
1
EFFECT OF
RATE OF FLOW ON RETARDING FACTOR
DATA SHEET
No IT
PLATE No 18
RATE OF FLOW GALS. / MIN.
10
20
30
40
50
60
70
80
90
100

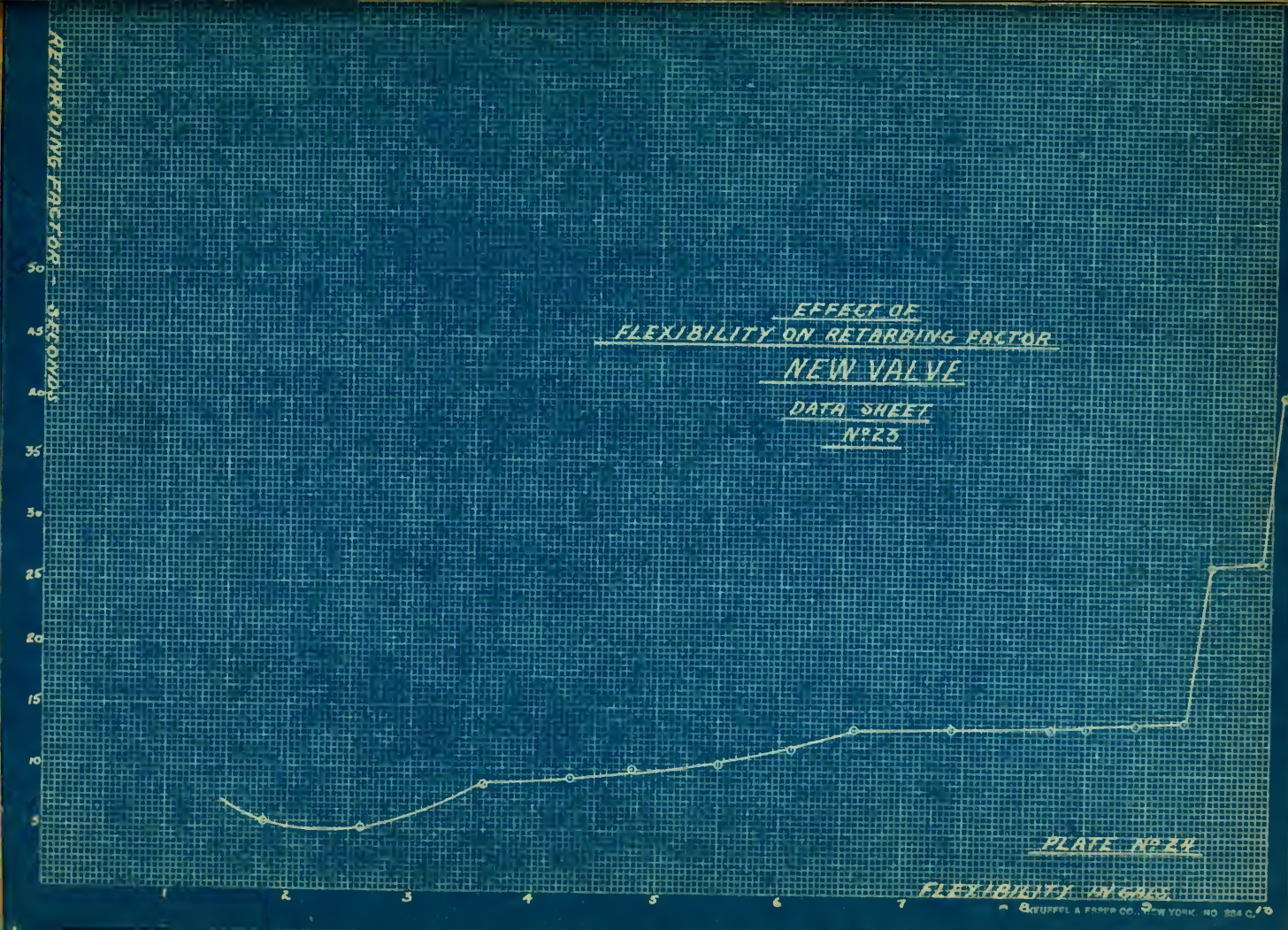

RETARDING FACTOR - SECONDS.
10
8
6
4
2
EFFECT OF
RATE OF FLOW ON RETARDING FACTOR
DATA SHEET
No 18
PLATE No 19.
100
200
300
RATE OF FLOW - GALS/MIN.
500
KEUFFEL & ESSER CO., NEW YORK. NO 324

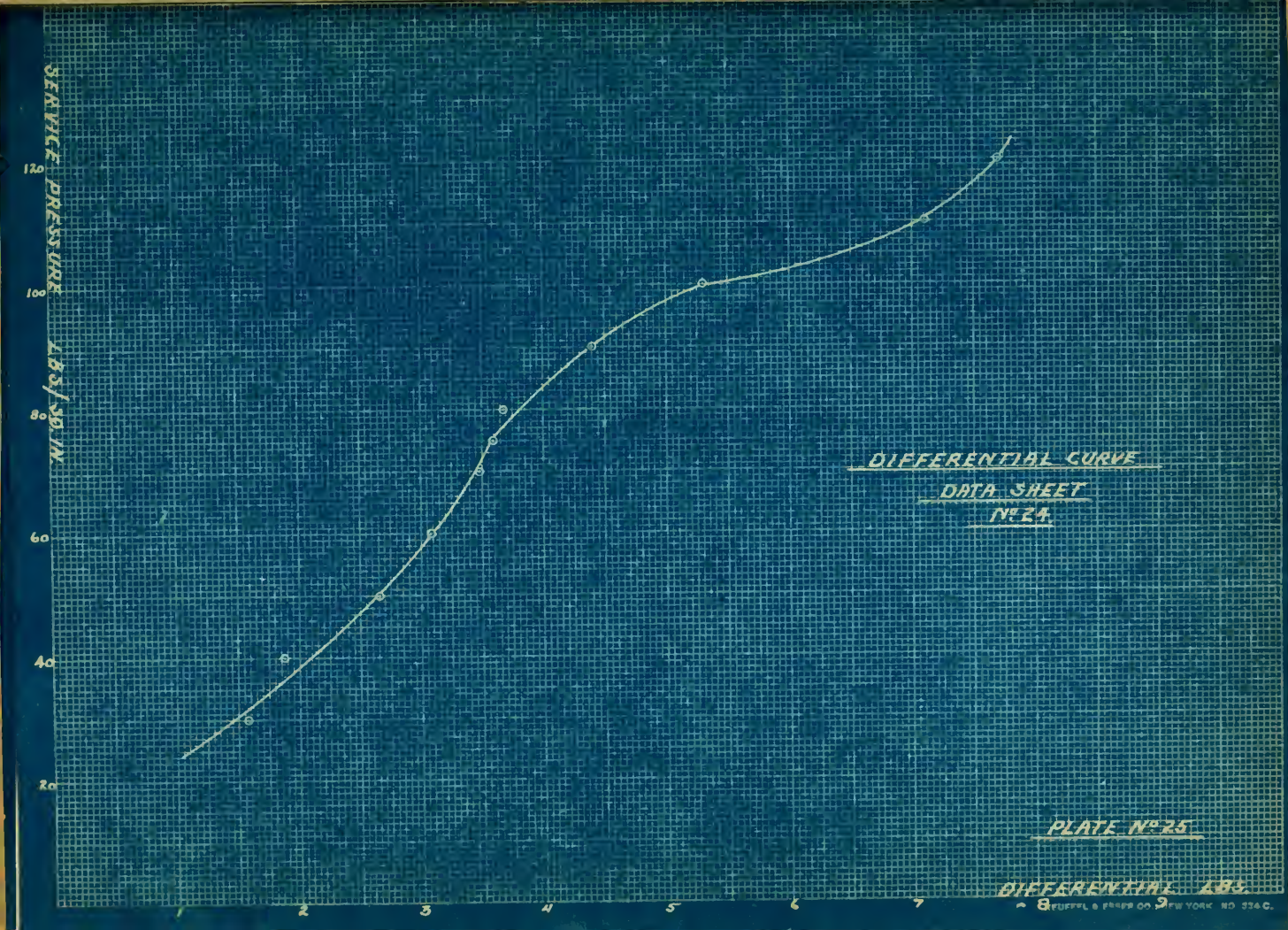

RETARDING FACTOR - SECONDS
24
20
16
12
8
4
100
200
300
RATE OF FLOW GAL/MIN
EFFECT OF
RATE OF FLOW ON RETARDING FACTOR
DATA SHEET
Nº 19
PLATE Nº 20
KEUFFEL & ESSER CO., NEW YORK. NO 834 O.


RETARDING FACTOR - SECONDS
28
24
20
16
12
8
4
100
200
300
RATE OF FLOW - GALS./MIN.
EFFECT OF
RATE OF FLOW ON RETARDING FACTOR.
DATA SHEET
No. 20
PLATE No. 21
KEUFFEL & ESSER CO., NEW YORK. NO. 334


RETARDING FACTOR IN SECONDS
EFFECT OF
FLEXIBILITY ON RETARDING FACTOR
DATA SHEET
No. 21
PLATE No. 22
FLEXIBILITY IN GALS.
KEUFFEL & ESSER CO., NEW YORK. NO. 334 G.


RETARDING FACTOR SECONDS
10
20
30
40
50
1
2
3
4
5
6
7
EFFECT OF
FLEXIBILITY ON RETARDING FACTOR
DATA SHEET
No. 22.
PLATE No. 23.
FLEXIBILITY IN GAGE.
KEUFFEL & ESSER CO., NEW YORK. NO. 324 G.


RETARDING FACTOR - SECONDS
50
45
40
35
30
25
20
15
10
5
1
2
3
4
5
6
7
EFFECT OF
FLEXIBILITY ON RETARDING FACTOR
NEW VALVE
DATA SHEET
No. 23
PLATE No. 24
FLEXIBILITY IN GMS.
KEUFFEL & ESSER CO., NEW YORK. NO. 324 G.


SERVICE PRESSURE LBS./SQ.IN.
120
100
80
60
40
20
1
2
3
4
5
6
7
DIFFERENTIAL CURVE
DATA SHEET
No. 24.
PLATE No. 25.
DIFFERENTIAL LBS.
KEUFFEL & ESSER CO. NEW YORK NO. 334 C.

---DATA SHEETS---

DATA SHEET No 1

Calibration of Pressure Tank.

Capacity of Tank 4500 Gallons.

Service Pressure Constant at 75#. Flexibility Constant. Water Level and Air Cushion Variable. Rate of Discharge Constant at 18.5 Gallons Per. Min.

No. of Gal in Tank.	Hg. Gauge Reading. L.	R.	L + R.	Head of Water. Feet.	Minimum Pr. for Alarm.
950	32.5	33.1	65.6	70.8	7.
1400	32.8	32.1	65.9	71.0	7.
1925	32.8	33.2	66.0	71.2	7.
2480	32.8	33.2	66.0	71.2	7.
2990	32.8	33.2	66.0	71.2	7.
3450	32.9	33.1	66.0	71.2	8.
3750	33.1	33.3	66.4	71.6	7.
4050	33.4	33.4	66.8	72.0	7.
4300	33.4	33.2	66.6	71.8	7.

DATA SHEET No 2.
CALIBRATION OF 6" STANDPIPE

L	R 55#	L+R	FT. HD	L	R 45#	L+R	FT HD.	FEET DIFF.	FLEX
4.8	6.4	11.2	12.7	.6	2.85	3.45	4.5	8.2	12.3
6.7	8.1	14.8	17.1	2.7	4.70	7.40	8.8	8.3	12.45
8.3	9.5	17.8	20.1	4.3	6.0	10.3	11.7	8.4	12.60
10.0	11.0	21.0	23.8	6.1	7.6	13.7	15.6	8.2	12.30
11.8	12.6	24.4	27.1	8.1	9.3	17.4	19.4	7.7	11.55
13.6	14.1	27.7	31.0	10.0	10.9	20.9	23.7	7.3	10.95
16.2	16.5	32.7	36.2	12.7	13.4	26.1	29.1	7.1	10.15
18.5	18.6	37.1	41.1	15.2	15.6	30.8	34.3	6.8	10.2
20.7	20.6	41.3	45.9	17.7	17.9	35.6	39.6	6.3	9.45
23.1	22.8	45.9	50.7	20.1	20.1	40.2	44.4	6.3	9.45
24.3	23.8	48.1	53.1	21.6	21.5	43.1	47.8	5.3	7.45
26.9	26.1	53.0	58.4	24.3	23.9	48.2	53.1	5.3	7.45
30.2	28.9	59.1	65.1	28.1	27.2	55.3	60.8	4.3	6.45
31.7	30.3	62.0	68.2	29.9	28.8	58.7	64.6	3.6	5.40
33.8	31.9	65.7	72.3	32.5	30.2	63.4	69.4	2.9	4.35
35.1	33.1	68.2	74.7	34.2	31.4	66.6	73.2	2.0	3.0
36.4	34.2	70.6	77.1	35.9	33.8	69.7	76.6	1.0	1.5

DATA SHEET No 5.

CALIBRATION OF 6" STAND PIPE.

75#				65#				DIFF. IN LEVEL FT.	FLEX.
L	R	L+R	FEET	L	R	L+R	FEET		
3.5	5.4	8.9	10.2	.4	2.7	3.1	4.07	6.13	9.195
5.7	7.2	12.9	14.78	2.5	4.5	7.0	8.03	6.48	9.72
7.8	8.9	16.7	18.85	4.6	6.3	10.9	12.62	6.23	9.34
9.5	10.5	20.0	22.45	6.5	8.9	14.5	16.60	5.95	8.92
10.6	11.5	22.1	24.60	7.9	9.1	17.0	19.35	5.25	7.87
12.65	13.3	25.95	28.95	9.8	10.8	20.6	23.20	5.75	8.62
14.2	14.7	28.9	32.3	11.5	12.25	23.75	26.55	4.76	8.62
16.1	16.4	32.5	36.16	13.3	14.0	27.3	31.40	4.30	7.14
18.0	18.2	36.2	40.0	15.7	16.1	31.8	36.70	4.05	6.45
19.4	19.35	38.75	42.65	17.2	17.4	34.6	38.60	4.09	6.07
20.8	20.6	41.4	45.55	18.7	18.8	37.5	41.46	3.84	6.13
22.2	21.9	44.1	48.65	20.3	20.2	40.5	44.81	3.60	5.76
23.8	23.5	47.3	52.02	22.0	21.8	43.8	48.42	3.33	5.40
26.0	25.3	51.3	56.85	24.4	24.0	48.4	53.5	2.37	4.99
28.2	27.2	55.4	60.64	26.8	26.0	52.8	58.27	2.40	3.55
29.9	28.7	58.6	64.50	28.7	27.7	56.4	62.1	2.67	3.60
31.9	30.4	62.3	68.30	31.0	29.7	60.7	65.67	2.67	2.50
33.8	32.0	65.8	72.2	33.1	31.5	64.6	70.75	1.45	2.17
35.6	33.5	69.1	77.04	35.2	33.2	68.4	76.10	.97	1.45

DATA SHEET No. A

CALIBRATION OF 6" STAND PIPE

100				90				DIFF. IN LEVEL FT.	FLEX.
L	R	L+R	FT. HO	L	R	L+R	FT HO		
5.2	6.7	11.9	13.82	2.8	4.7	7.5	8.50	4.82	6.23
6.2	7.5	13.7	15.5	3.9	5.6	9.5	10.43	5.07	7.60
8.3	9.3	17.6	19.55	6.0	7.5	13.5	15.25	4.30	6.45
9.1	10.1	19.2	21.29	7.0	8.2	15.2	16.92	4.37	6.55
11.7	12.4	24.1	25.75	9.5	10.5	20.0	21.95	4.81	7.21
13.1	13.7	26.8	29.91	11.2	12.0	23.2	25.32	4.59	6.88
14.0	14.5	28.5	31.58	12.3	12.9	25.2	27.75	3.83	5.74
15.8	16.0	31.8	35.43	13.9	14.4	28.3	31.11	4.32	6.48
18.9	18.8	37.7	41.65	17.2	17.4	34.6	38.32	3.35	5.02
20.5	20.4	40.9	45.05	19.1	19.1	38.2	41.15	3.90	5.85
22.6	22.2	44.8	49.35	21.2	21.0	42.2	45.98	3.37	6.05
24.4	23.8	48.2	52.75	23.2	22.8	46.0	50.35	2.40	3.60
27.5	26.4	53.7	59.0	26.3	25.6	51.9	57.05	1.95	2.92
29.7	28.5	58.2	63.78	28.9	27.8	56.7	61.85	1.53	2.29
31.5	29.8	61.1	66.65	30.6	29.3	59.9	65.45	1.20	1.80
32.0	31.3	64.3	70.5	32.02	30.9	63.4	69.55	.95	1.42
34.0	32.8	67.6	73.35	34.02	32.5	66.9	73.35	0	0
36.0	33.7	69.7	76.25	35.83	33.6	69.4	76.25	0	0

DATA SHEET NO5

Effect Of Flexibility On The Sensitiveness Of A Four Inch Grinnell Variable Pressure Alarm Valve. Circuit Closer Only. Service Pressure Constant At 75#.

Ft. Head In S.P. Above O Of Gauge.	Flexibility. In Gal.	Sensitiveness In Gal.
38.45	6.9	0.0
45.48	6.1	0.0
51.44	5.4	0.0
54.85	4.9	11.2
59.79	4.2	18.5
55.30	4.9	17.0
65.75	3.4	19.6
70.90	2.4	20.8
76.85	1.2	12.3
59.30	4.4	18.5
71.70	2.3	20.8
72.6	2.1	15.7

DATA SHEET No 6.

NEW VALVE.

Effect Of Flexibility On The Sensitiveness Of A Four Inch Grinnell Variable Pressure Alarm Valve. Circuit Closer Only. Service Pressure Constant At 75#.

Ft. Head In S.P. Above 0 Of Gauge.	Flexibility In Gal.	Sensitiveness In Gal.
7.32	9.9	.0
11.66	9.6	34.0
14.75	9.3	30.0
20.45	8.8	30.6
27.10	8.2	27.5
34.24	7.6	26.5
41.9	6.6	25.5
45.75	6.1	23.0
55.40	4.9	22.0
66.90	3.7	19.5
74.6	1.6	8.0

DATA SHEET No7

Effect Of Flexibility On The Sensitiveness Of A Four Inch Rockwood Variable Pressure Alarm Valve. Circuit Closer Only. Service Pressure Constant At 75#.

Ft. Head In S.P. Above 0 Of Gauge.	Flexibility In Gal.	Sensitiveness In Gal.
58.2	4.5	0.0
60.1	4.2	21.0
61.0	4.1	23.0
63.0	3.8	24.0
64.9	3.5	24.0
66.8	3.2	22.0
67.3	3.1	21.0
68.7	2.9	21.0
65.9	3.3	22.0
68.4	3.0	22.0
71.6	2.3	18.5
72.5	2.1	15.7
75.0	1.5	5.2

DATA SHEET No 8.

Effect Of Flexibility On The Sensitiveness Of A Four Inch Rockwood Variable Pressure Alarm Valve. Circuit Closer Only. Service Pressure Constant At 75#.

Ft. Head In S.P. Above 0 Of Gauge.	Flexibility In Gal.	Sensitiveness In Gal.
66.6	3.2	7.5
67.9	3.0	9.6
68.9	2.8	10.3
70.8	2.5	9.6
71.3	2.4	9.0
71.8	2.1	8.7
74.1	1.7	8.0
75.0	1.5	7.5
7[illegible].5	1.0	6.4
	0.0	2.2

DATA SHEET Nº 9

System Set As In Previous Tests; 75# Service Pressure, Air Pumped Into Standpipe to 75# and Water Turned In. Head In Standpipe, 37 Feet Of Water. Flexibility 7. Water Removed Through Drain, 4 Gal At A Time. Pressure Read Afte r Each Removal.

Gal. Removed.	Pressure In # per. sq. in.
0.	125.0
4.	112.0
8.	102.5
12.	93.0
16.	85.0
20.	80.0
24.	75.0
28.	69.0
32.	65.0
36.	60.0
40	55.5
44.	52.0
48.	48.0
52.	45.0
56.	42.0
60.	39.0
64.	35.5
68.	33.0
72.	30.5
76.	28.0
80	26.0
84.	24.5
88.	23.0
92.	21.5
96.	20.0
100.	19.0
104.	18.0
108.	17.5
112.	17.0
116.	16.0
120	15.0
124.	14.5
128.	14.0
132.	13.0
136.	12.5
140	12.0
144.	11.0
148.	10.5
152.	10.0
156.	9.7
160.	0.0

DATA SHEET N°10

Effect Of Varying The Service Pressure On The Retarding Factor Of A Four Inch Grinnell Variable Pressure Alarm Valve, Or Content Of The System Kept Constant.

Pressure Set At 7, Rate Of Flow 25 Gal Per Min.

Service Pr.	Retarding Factor. In Sec.	No. Of Drops Before Alarm.
[illegible]	.6	1
[illegible]	1.6	1
100.0	1.8	1.
90.0	2.0	1.
80.0	2.4	1.
70.0	2.4	1.
60.0	2.8	1.
50.0	29.2	3.
59.0	3.0	1.
58.0	3.0	1.
57.5	3.4	1.
56.5	3.4	3.4
56.0	4.2	3.
55.0	15.2	4.
53.0	27.0	3.
52.0	27.6	3.
51.0	27.6	3.
50.0	29.2	3.
50.0	40.0	4.
47.0	51.4	5.
45.0	65.0	7.
42.0	50.6	5.

DATA SHEET No. 11

Effect Of Varying The Service Pressure On The Retarding Factor Of A Four Inch Viking Variable Pressure Alarm Valve. Air Content Of The System Kept Constant. Flexibility Set At 3.8 Rate Of Flow 95 Gal. Per. Min.

Service Pr. Lbs.	Retarding Factor. In Sec.	No. Of Snaps Before Alarm.
120.	5.4	2.
110.	5.6	3.
100.	6.1	2.
90.	6.8	2.
80.	8.0	2.
70.	8.8	2.
60.	10.4	2.
50.	12.8	2.
45.	34.2	4.
47.	34/0	4.
49.	23.0	3.
14.	54.4	6.
43.	70.4	7.
41.	196.2	17.
40.		

DATA SHEET No 12.

Effect Of Varying The Service Pressure On The Retardi ng Factor Of A Four Inch Grinnell Alarm Valve.

Air Content Of The System Kept Constant. Flexibility Set At 4.45 Rate Of Flow 25 Gal. Per. Min.

Service Pr. Lbs.	Retarding Factor. In Sec.	No. Of Snaps. Before Alarm.
120.	1.6	1.
110.	1.8	1.
100.	1.8	1.
90.	2.0	1.
80.	2.0	1.
70.	2.2	1.
65.	2.6	1.
60.	11.4	2.
55.	12.0	2.
50.	22.8	2.
45.	23.0	3.
40.	35.4	4.

DATA SHEET No 13

Effect Of Varying The Service Pressure On The Retarding Factor Of A Four Inch Grinnell Alarm Valve. Air Content Of The System Constant. Flexibility Set At 4.1. Rate Of Flow Constant At 25 Gal. Per. Min.

NEW VALVE USED IN THIS TEST.

Service Pr. Lbs.	Retarding Factor. In Sec.	No Of Snaps Before Alarm.
120.	10.8	2.
110	11.6	3.
100.	12.8	3.
90.	14.0	3.
80.	15.6	3.
70.	22.0	3.
60.	19.4	3.
50.	23.4	3.
40.	105.0	

DATA SHEET No 14

Effect of Rate of Flow on the Retarding Factor of a Four Inch Grinnell Variable Pressure Alarm Valve.

Circuit Closer Only. Service Pr. Constant at 75#.

Head in Standpipe,(Feet of Water) 20.5

Flexibility, 8.8.

Flow in Gal. Per. Min.	Retarding Factor.
10.0	2
15.7	2
20.0	2
30.6	2
42.0	2
53.0	2
60.0	2
114.0	2
84.0	2
145.0	2
162.0	2
200.0	2
300.0	2
410.0	2
500.0	2

DATA SHEET No 15

Effect of Rate of Flow on The Retarding Factor of A Four Inch Grinnell Variable Pressure Alarm Valve.

Circuit Closer Only. Service Pr. Constant at 75#.

Head in the Standpipe,(Feet of Water), 38.

Flexibility, 6.8.

Flow in Gal. Per. Min.	Retarding Factor in sec.
6.4	2.4
9.0	2.4
12.5	2.4
15.4	2.4
22.0	2.4
25.6	2.4
30.6	2.4
40.0	2.0
50.0	2.0
60.0	2.0
80.0	2.0
100.0	2.0
120.0	2.2
140.0	2.2
200.0	2.2
300.0	2.2
400.0	2.2
500.0	2.2

DATA SHEET No.16

Effect Of Rate Of Flow On The Retarding Factor Of A Four Inch Grinnell Variable Pressure Alarm Valve.

Circuit Closer Only. Service Pr. Constant at 75#.

Head In The Standpipe, 60.2 Feet of Water.

Flexibility, 4.2

Flow In Gal. Per. Min.	Retarding Factor In Sec.
18.5	12.6
19.6	11.4
22.0	11.0
26.5	3.0
30.6	2.0
24.0	10.8
23.0	10.0
25.0	9.2
27.5	2.0
5(.0	2.0
60.0	2.0
75.0	2.0
100.0	2.0

Same Conditions Except Head Of Water In Standpipe Was Changed To 56. Feet Flexibility, 4.8

10.0	2.0
13.0	2.0
15.0	2.0
20.0	2.0

DATA SHEET N°17

Effect Of Rate Of Flow On The Retarding Factor Of A

Four Inch Grinnell Alarm Valve.

Circuit Closer Only. Service Pr. Constant at 75#.

Head In The Standpipe, 67 Feet Of Water.

Flexibility, 3.2

Flow In Gal. Per Min.	Retarding Factor In Sec.
20.0	9.4
26.5	7.6
24.0	8.0
29.0	6.6
30.6	6.0
36.5	5.0
40.0	2.0
49.0	2.0
60.0	2.0
75.0	2.0

DATA SHEET Nº18

Effect Of Rate Of Flow On The Retarding Factor Of A Four Inch Grinnell Variable Pressure Alarm Valve.

Circuit Closer Only. Service Pr. Constant at 75#.

Head In Standpipe 70.1 Feet of Water.

Flexibility, 2.6

Retarding Factor in sec.	Flow in Gal. Per. Min.
8.4	21.
8.2	23.
6.8	30.
6.2	33.
6.2	40.
5.4	55.0
3.4	65.
2.2	75.
2.0	100.
2.0	200.
2.0	300.
2.0	400.
2.0	500.

DATA SHEET No 19.

Effect Of Rate Of Flow On The Retarding Factor Of A Four Inch Grinnell Variable Pressure Alarm Valve.

Circuit Closer Only. Service Pr. Constant at 75#.

Head In Standpipe 74 Feet Of Water.

Flexibility, 1.7

Flow In Gal. Per. Min.	Retarding Factor In Sec.
15.7	21.0
22.0	13.4
18.5	20.4
26.5	9.0
30.6	8.2
40.0	5.0
50.0	2.0
75.0	2.0
100.0	2.0
200.0	2.0
300.0	2.0

1/10/10.

DATA SHEET NO20

Effect Of Rate Of Flow On The Retarding Factor Of A Four Inch Grinnell Variable Pressure Alarm Valve.

Circuit Closer Only. Service Pr. Constant at 75#.

Head In Standpipe, 76 Feet of Water.

Flexibility 1.3

Flow In Gal. Per. Min.	Retarding Factor In Sec.
12.3	27.8
14.0	22.4
15.7	17.4
22.0	10.4
26.5	6.8
30.6	5.2
33.0	3.2
40.0	2.0
55.0	2.0
65.0	2.0
75.0	2.0
100.0	2.0
200.0	2.0
300.0	2.0
400.0	2.0
500.0	2.0

DATA SHEET No 21

Effect of Flexibility On The Retarding Factor Of A Four Inch Grinnell Variable Pressure Alarm Valve.

Circuit Closer Only. Services Pr. Constant At 75#.

Rate Of Flow Constant At 25 Gallons Per. Minute.

Head In S.P. Ft. of Water.	Flexibility. In Gal.	Retarding Factor In Sec.	No Of Snaps of clapper.
50.5	5.5	2.2	1.
51.5	5.4	2.2	1.
53.5	5.1	2.2	1.
56.4	4.8	2.2	1.
60.2	4.2	2.2	1.
62.1	3.9	2.2	1.
63.0	3.8	2.2	1.
63.5	3.7	9.2	2.
66.9	3.2	8.2	2.
68.3	3.0	7.8	2.
69.3	2.8	7.6	2.
70.7	2.5	6.6	2.
72.4	2.2	10.2	3.
72.6	2.1	9.0	3.
74.0	1.5	8.8	3.
75.0	1.5	7.8	3.
76.0	1.3	6.0	3.
77.0	1.1	7.0	4.

DATA SHEET No 22.

NEW VALVE.

Effect Of Flexibility On The Retarding Factor Of A

Four Inch Grinnell Variable Pressure Alarm Valve.

Circuit Closer Only. Service Pr. Constant At 75#.

Rate Of Flow Constant At 25 Gallons Per. Min.

Head In S.P. Ft. Of Water.	Flexibility. In Gal.	Retarding Factor In Sec.	No Of Snaps Before Alarm.
40.54	6.6	37.4	4.
45.35	6.1		
50.4	5.5	33.8	4.
56.13	4.8	21.0	3.
59.53	4.3	18.6	3.
64.33	3.6	16.2	3.
70.03	2.6	9.0	2.
73.93	1.8	12.4	3.

DATA SHEET No 23

NEW VALVE.

Effect Of Flexibility On The Retarding Factor Of A Four Inch Variable Pressure Alarm Valve.

Circuit Closer Only. Service Pr. Constant At 75#.

Rate Of Flow Constant At 34 Gallons Per. Minute.

Head In S.P. Ft. Of Water.	Flexibility. In Gal.	Retarding Factor In Sec.	No Of Snaps Before Alarm.
6.65	10/2	40.6	4.
7.63	9.9	27.4	4.
12.43	9.5	27.0	3.
15.53	9.3	14.4	3.
19.63	8.9	14.0	2.
23.96	8.5	13.6	2.
27.50	8.2	13.4	2.
34.53	7.4	13.4	2.
40.54	6.6	13.4	2.
45.35	6.1	11.8	2.
50.40	5.5	10.8	2.
56.13	4.8	10.0	2.
59.53	4.3	9.2	2.
64.33	3.6	8.6	2.
70.03	2.6	5.0	1.
73.93	1.8	5.4	2.

DATA SHEET No 24.

Differential Of A Four Inch Grinnell Variable Pressure Alarm Valve. Head In The Standpipe, Flexibility And Rate Of Flow Constant.

Service Pr. Lbs.	Mercury Gauge Reading. L.	R.	L	R.	Differential. Lbs.
120.	10.2	5.5	15.7		7.708
110.	9.6	5.0	14.6		7.168
100.	7.9	2.9	10.8		5.303
90.	7.0	2.0	9.0		4.419
80.	6.2	1.3	7.5		3.682
75.	6.1	1.2	7.3		3.584
70.	6.1	1.0	7.1		3.486
60	5.6	.7	6.3		3.093
50.	5.2	.2	5.4		2.651
40.	4.4	.6	3.8		1.866
30.	4.2	.1	3.2		1.571